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IRON AND STEEL AT PARIS.

THE report of Assistant Commissioner J. D. Morrell, on the exhibits of iron and steel at the Paris Exhibition, has been submitted to the Secretary of State.

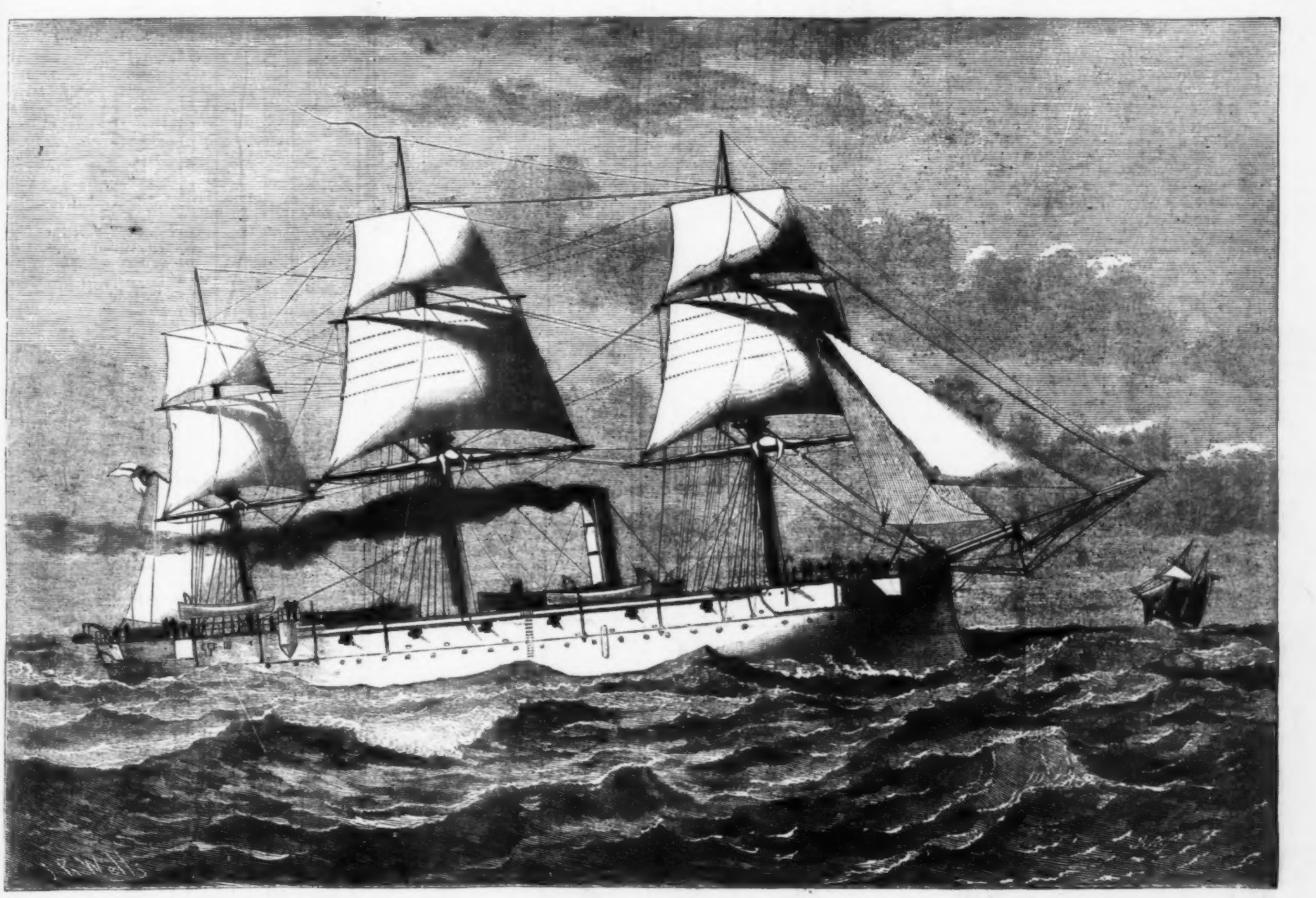
The leading iron and steel producing countries of the world, in the order of their importance, are enumerated as follows: Great Britain, United States, Germany, France, Belgium, Austria and Hungary, Russia, and Sweden. These countries produce 98½ per cent. of the world's annual product of iron and steel, and all were represented at the Paris Exhibition except Germany.

In his general survey of the exhibits in this department, Mr. Morrell says that they presented very little that was new to the practical man who is engaged in the manufacture of these products. There were evidences of progress in the dephosphorization of iron, in the substitution of machine for hand puddling, in the simplification and perfection of the open-hearth process, in the casting of steel, in the manufacture of wrought iron and steel, and their application to new uses; but no absolutely new process for the manufacture of iron and steel was exhibited or described. The metallurgical world, he says, has apparently reached a resting place in the matter of invention, and steel-makers everywhere seem to have reached the conclusion that in the improvement of present processes, and in the extension of the use of iron and steel, are they to find problems worthy of their attention in the future. The display of iron and steel products at the Paris Exhibition has never been equaled in a World's Fair, while the exhibits of machinery have only been surpassed by that made at Philadelphia, which was more extended and more varied than that of Paris, and had the additional advantage of being more generally in motion. At the same time, the Paris Exhibition demonstrated more fully than that at Philadelphia or any previous one, the efficiency of machinery in all industrial enterprises, and exhibited the efforts of every progressive nation to obtain the best machinery for its own service, and the necessity brought upon all by their active competition to adopt every new device and improvement which tends to increase, perfect, and cheapen products.

Touching new uses of iron Mr. Morrell says that the most important relates to the introduction of various systems of iron permanent way for railroads, in the place of wooden crossties and stringers which are now generally in use. In one or two of these systems steel is substituted for iron. The commissioner thinks that it is not improbable that one or two of these systems will become popular, and even necessary, in countries which do not possess an abundance of timber, but at present many objections are made to their adoption. The use of iron in the place of wood in the construction of buildings, and also of bridges, telegraph poles, and in mining operations, is increasing every year in Europe. Mr. Morrell also mentions the manufacture of mineral fuel from the culm of coal, which in several European countries is a rapidly developing industry. In this country, however, he thinks that the abundance and cheapness of good coal will long operate as an impediment to the utilization of the dust which has accumulated or may accumulate in the vicinity of coal mines.

ALLOTROPY OF METALS.

M. SCHÜTZENBERGER, in his investigations of the different molecular states of metals, finds that other metals than antimony, especially copper, lead, and silver, take allotropic forms when precipitated from saline solutions, by electrolysis or otherwise. He predicts that this will prove to be the case with a large majority of metals. The less active and more stable modification is formed at the expense of the other, with loss of heat, like red phosphorus from ordinary phosphorus, or oxygen from ozone. Allotropic copper, when oxidizing in the air, takes brilliant rainbow hues, which may have a valuable industrial application.—*Bull, de la Soc. d'Encour.*



H. M. S. COMUS, ONE OF THE SIX NEW STEEL CORVETTES BUILT AT GLASGOW, FOR THE ROYAL NAVY.

H. M. S. COMUS.

THIS ship is one of six new corvettes, built of steel and iron, sheathed with wood, constructed for the Royal Navy by Messrs. John Elder & Co., at Govan, on the Clyde, near Glasgow. The names of the six are the Comus, Champion, Cleopatra, Curaçoa, Conquest, and Carysfort, which have all been launched, and most of them are completed ready for sea. These vessels are built with iron framing and steel plating, and sheathed with a double thickness of wood. Being intended for foreign service, they are coppered outside so as to require docking as seldom as possible for the purpose of cleaning. They are ship-rigged; and, the propeller being made to lift, they can be used as sailing vessels when necessary. They present several novel features. They are fitted with a spare rudder aft, under the screw-shaft; this rudder is intended to be used only in the case of the main rudder being damaged. The engine, magazine, and boiler spaces in these vessels are protected by a shell-proof deck of steel, 1½ in. thick; all the openings through this deck are fitted with shutters or gratings, also shell-proof. In order further to protect these parts of the ship, the coal bunkers are fitted at the sides of the vessel, offering a considerable resistance to any shot entering the vessel; while, the bunkers themselves being water-tight and subdivided into compartments, the damage would be confined to one part. The stem and stern posts of the vessel consist of solid gun metal castings; the stem below water projects beyond the vessel forming a ram. The dimensions of the Comus are: Length between perpendiculars, 225 ft.; extreme breadth, 44 ft. 6 in.; depth, moulded, 24 ft.; draught of water, 18 ft. 6 in. aft, 17 ft. forward; displacement, 2,377 tons. The engines of the Comus are compound, surface-condensing, horizontal engines, having three cylinders, with 2 ft. 9 in. stroke, and are guaranteed to show 2,300 horse power indicated. Messrs. J. Elder & Co. are supplying the machinery for the three first vessels, the other three being supplied by Humphrey, Tennants & Co., of London. The engines are compound surface-condensing, with three cylinders, and are intended to give fully 2,300 indicated horse power; with this power the vessel will be propelled at the rate of thirteen knots per hour. There are six boilers, arranged in two water-tight compartments, so that either set of three can be used without the other, in case of accident. The armament consists of two 90-cwt. guns and twelve 64-pounder guns. One of the 90-cwt. guns is fitted up in the forecastle, and fires all round the bow, the other being fitted up under the poop; the 64-pounders are on the upper deck, six on each side. The Comus, Champion, and Carysfort have been built under the superintendence of Mr. J. Sutton; and the Cleopatra, Curaçoa, and Conquest under that of Mr. J. B. Huddy, Admiralty overseer. Each vessel carries eight small boats, one a steam launch, and one a pinnace. There is a torpedo port fitted in the poop.—*Illustrated London News.*

LIGHT DRAUGHT, FAST, STERN WHEEL STEAM YACHT.

IN our SUPPLEMENT No. 172 we gave a preliminary drawing and brief description of a yacht of the above description, built at Rock Island, Ill. We now have the pleasure of presenting drawings more in detail, showing the construction, with full particulars, for which, as given below, we are indebted to M. Meigs, U. S. Civil Engineer, by

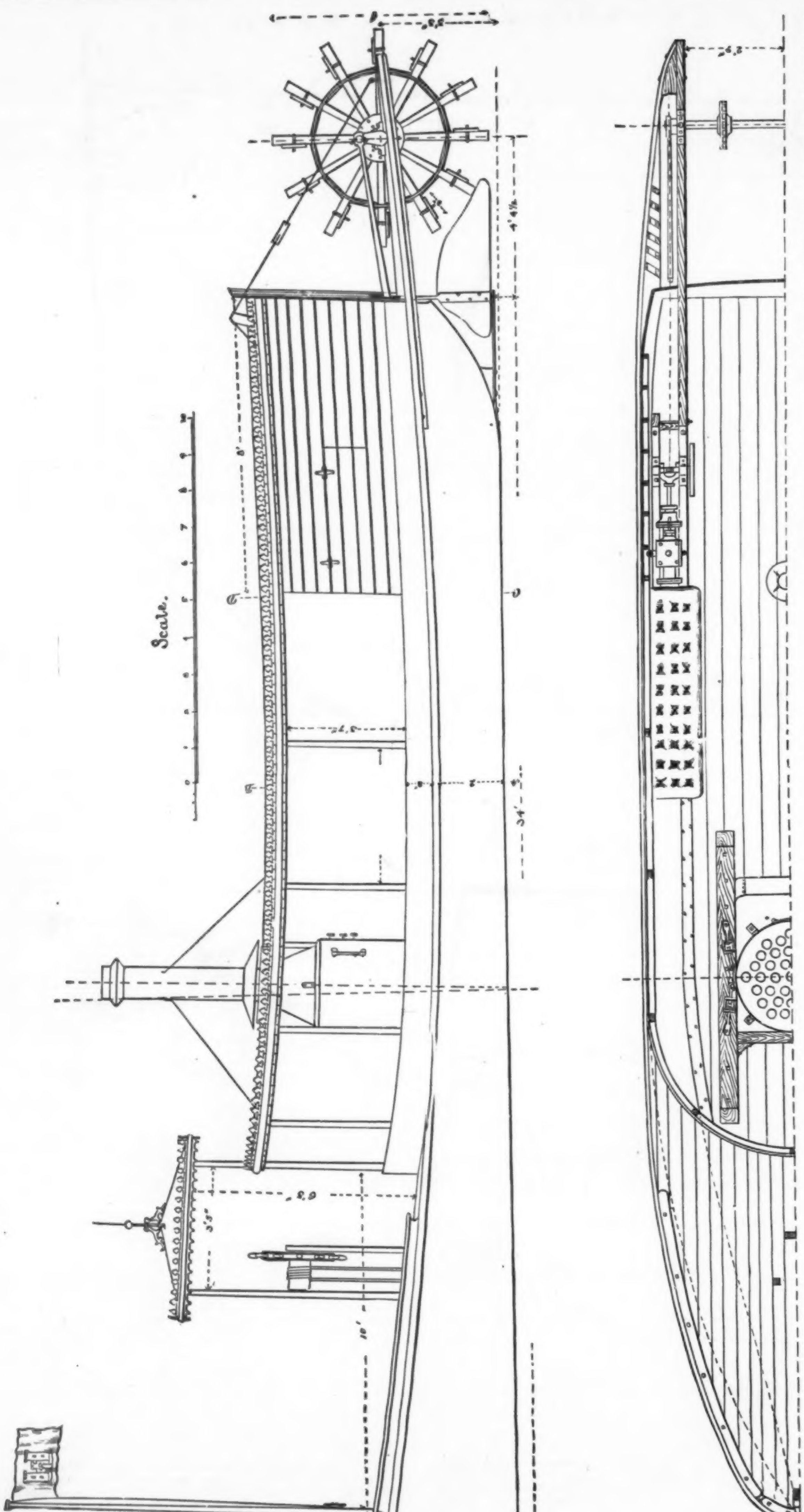


FIG. 1.—LIGHT DRAUGHT STERN WHEEL STEAM YACHT.—DESIGNED BY M. MEIGS, U. S. CIVIL ENGINEER, UNDER DIRECTION OF COL. F. W. FARQUHAR, U. S. A., BUILT AT ROCK ISLAND, ILL.

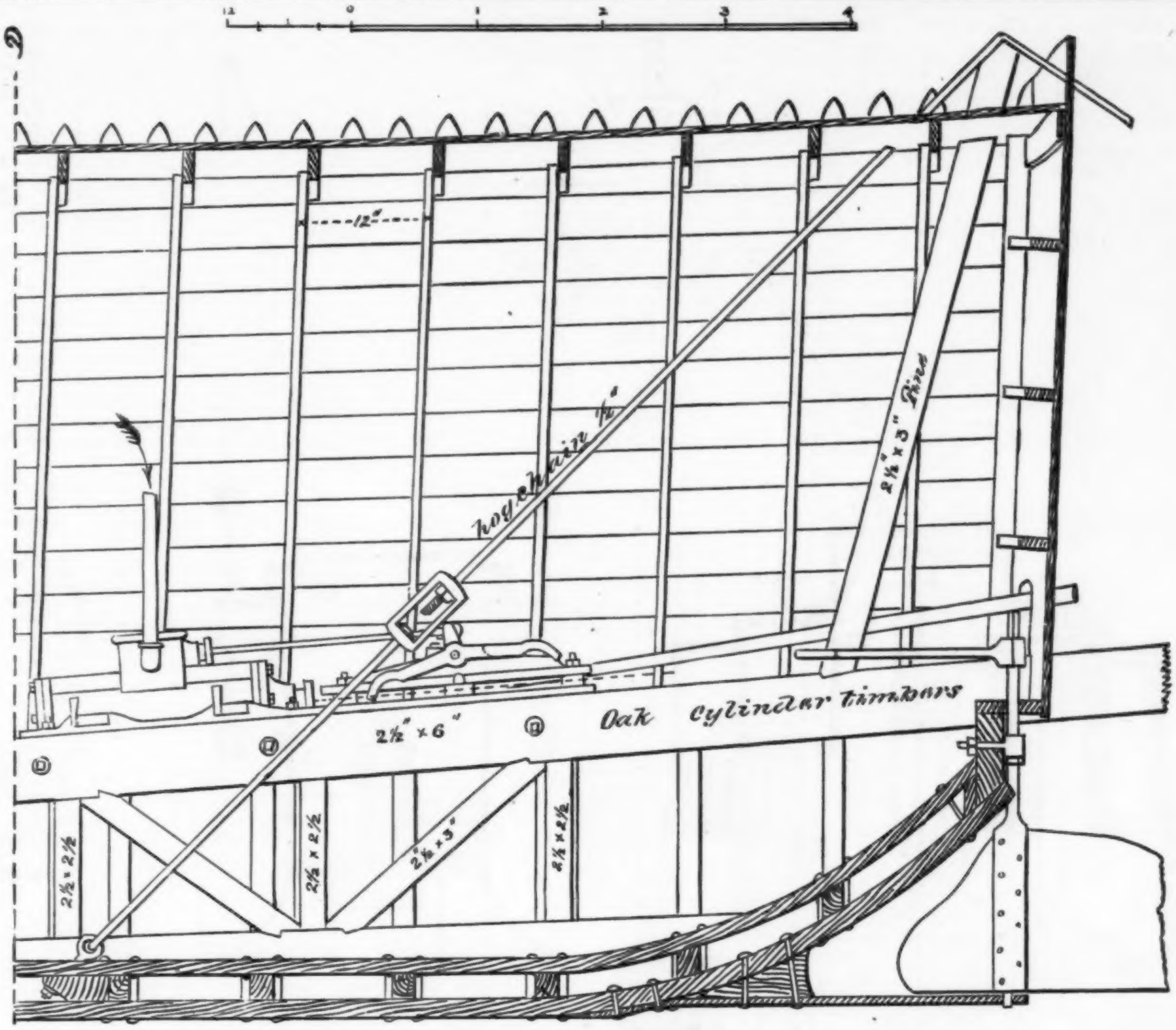


FIG. 2.–STERN WHEEL STEAM YACHT.

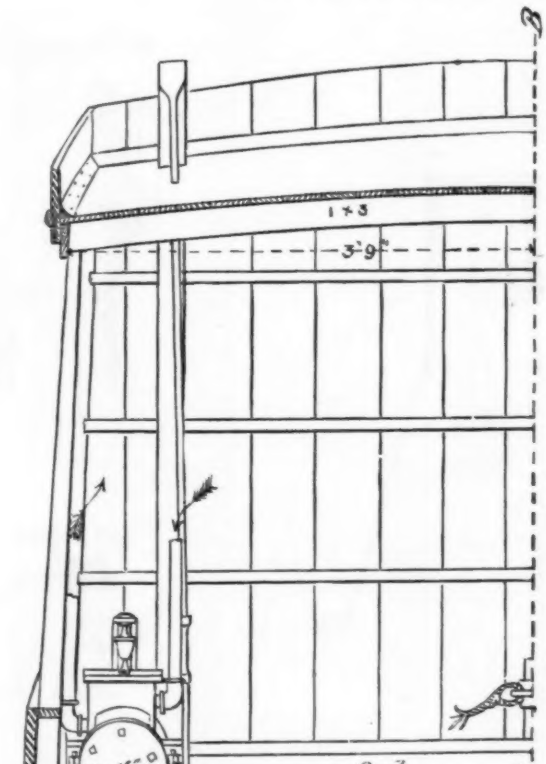


FIG. 3.- STERN WHEEL STEAM YACHT.

whom the vessel was designed, under direction of Colonel F. W. Farquhar, Corps of Engineers, U. S. A.

The light draught of these boats, their excellent speed, and economy of construction, render them admirably adapted for use on many waters where other forms of steam vessels cannot float.

DESCRIPTION OF STEAM LAUNCHES, DESIGNED, UNDER DIRECTION OF COL. F. W. FARQUHAR, CORPS OF ENGINEERS, U. S. ARMY, BY M. MEIGS, U. S. CIV. ENG.

Boat—	
Length of hull	34 ft.
" " wheel included	41 ft. 5 in.
Beam at gunwale	8 ft. 2 in.
" " bottom (flat)	5 ft. 10 in.
Depth of hull (midships)	24 in.
Draught	about 16 in.
Float timbers	2½ x 1½ in.
Ribs	2½ x 1½ in.
Outside planking	1 in.
Bottom " oak	1 in.
Keelson	1¼ in.
Keel (strake)	1½ in.
Wheel—	
Diameter	6 ft.
Number buckets	12.
Length	5 ft. 2 in.
Width	8 in.
Thickness	⅝ in.
Engines—	
Diameter cylinders	4½ in.
Length stroke	16 in.
Diameter steam pipe	1½ in.
" exhaust pipe	2 in.
Valve motion worked from crosshead.	
Boiler—	
Outside diameter	30 in.
Height	60 in.
Diameter fire box	26 in.
Depth "	22 in.
Sheet iron	¼ in.
Flue sheets and fire box, steel	⅜ in.
Number tubes (iron)	66.
Diameter tubes	2 in.
Square feet grate surface	$3\frac{68}{100}$ sq. ft.
Heating surface	100.
Horse power	$7\frac{3}{10}$.
Boiler Attachments—	
One Hancock inspirator	No. 10.
One whistle	3 in. bell.
One spring safety valve	1¼ in.

Engineer Meigs also adds the following information:

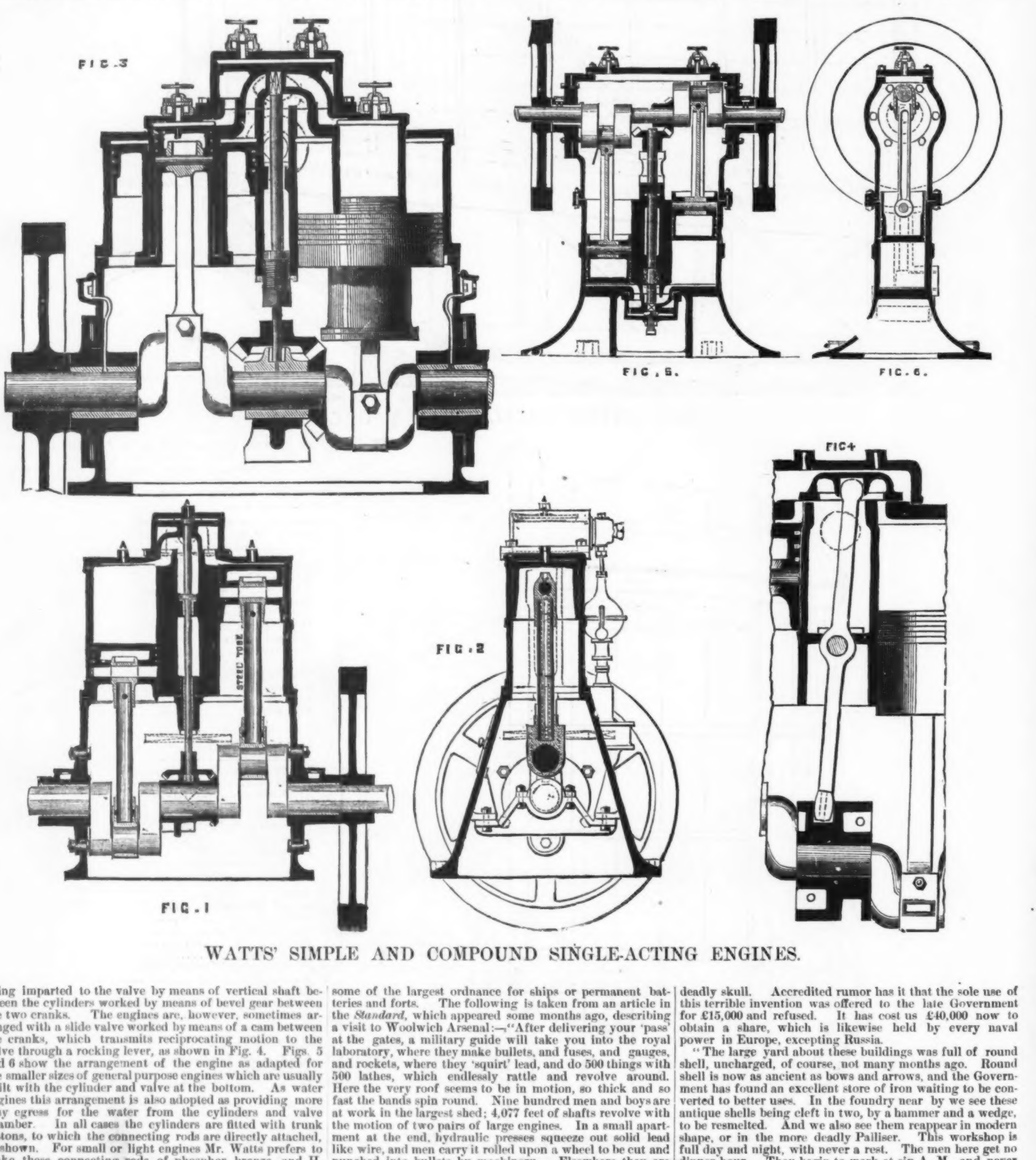
We had considerable trouble with leaky flues, owing to inexperienced engineers, and I would recommend a boiler with submerged flues and conical inside smoke box, as less likely to give trouble in general. After our engineers learned how to manage these boilers we heard no complaint.

The speed of these boats has not been well measured, as they have only been run on the Mississippi, where there is a strong current. One of them was reported as having run 13 measured miles in one hour down stream. On a trip up stream one of the boats ran 243 miles in 58½ running hours, an average of $4\frac{14}{100}$ miles per hour up stream, with a current

against her varying from $1\frac{1}{8}$ to 5 miles per hour. Her greatest speed up stream on the trip was $5\frac{87}{100}$ miles per hour, and her least $3\frac{3}{10}$. The boats will average, I think, seven miles per hour in still water, with 100 pounds steam, but when crowded can go faster. The boats cost about $1,000 each.

SINGLE ACTING SIMPLE AND COMPOUND ENGINES.

THE illustrations below show some very neat examples of small engines, designed by Mr. T. C. Watts, of Leaden-hall street, London, for the many kinds of work to which small engines are now applicable, one of the forms being specially designed for launch and torpedo boats. We do not give an exterior view of either engine, but it will be gathered from the different sections that the whole of the working parts are inclosed, and that the engine presents a very neat appearance. In our illustrations, Figs. 1 and 2 show vertical sections through the cylinders and frame, respectively along and transverse to the crank shaft, of a double-cylinder single acting simple engine. Fig. 3 is a vertical section along the crank shaft of a double-cylinder single-acting compound engine. In this and in Figs. 5 and 6 the distributing valve is circular, with a rotary action, the motion being imparted to the valve by means of vertical shaft between the cylinders worked by means of bevel gear between the two cranks. The engines are, however, sometimes arranged with a slide valve worked by means of a cam between the cranks, which transmits reciprocating motion to the valve through a rocking lever, as shown in Fig. 4. Figs. 5 and 6 show the arrangement of the engine as adapted for the smaller sizes of general purpose engines which are usually built with the cylinder and valve at the bottom. As water engines this arrangement is also adopted as providing more easy egress for the water from the cylinders and valve chamber. In all cases the cylinders are fitted with trunk pistons, to which the connecting rods are directly attached, as shown. For small or light engines Mr. Watts prefers to make these connecting rods of phosphor bronze, and H-shaped in transverse section, as shown in Figs. 3, 5, and 6, but for large engines the connecting rods are made of steel tubes, with heads or ends of phosphor bronze, as seen in Figs. 3 and 4. It is unnecessary to explain the action of the engine, as our illustrations are so complete, but it may be mentioned that the exhaust steam is not passed into the box inclosure formed by the engine frame, but is exhausted into the atmosphere or into a condenser in order to keep the space in which the working parts are inclosed free from steam, so that leakage from the cylinders may be easily detected, and so that the parts may be examined without inconvenience. The exhaust ports are most clearly shown in Fig. 3. When a reversing arrangement is required, the valve stem is divided into two parts connected to a long sleeve by cotters or pins; inside this sleeve are spiral grooves, into which the cotters or pins fit in such manner that when the sleeve is raised or lowered the upper part of the stem, and with it the valve, will be shifted or turned through half a revolution on its seat, thereby making the necessary alterations between the relative positions of crank and valve. In the compound engines shown in Fig. 3 the small and large cylinders are concentric with each other, and the pistons of the large cylinders annular. The pistons are provided at their lower ends with flanges, by means of which the pistons are secured to each other, so that the two pistons act jointly on the crank through one connecting rod.—*The Engineer.*



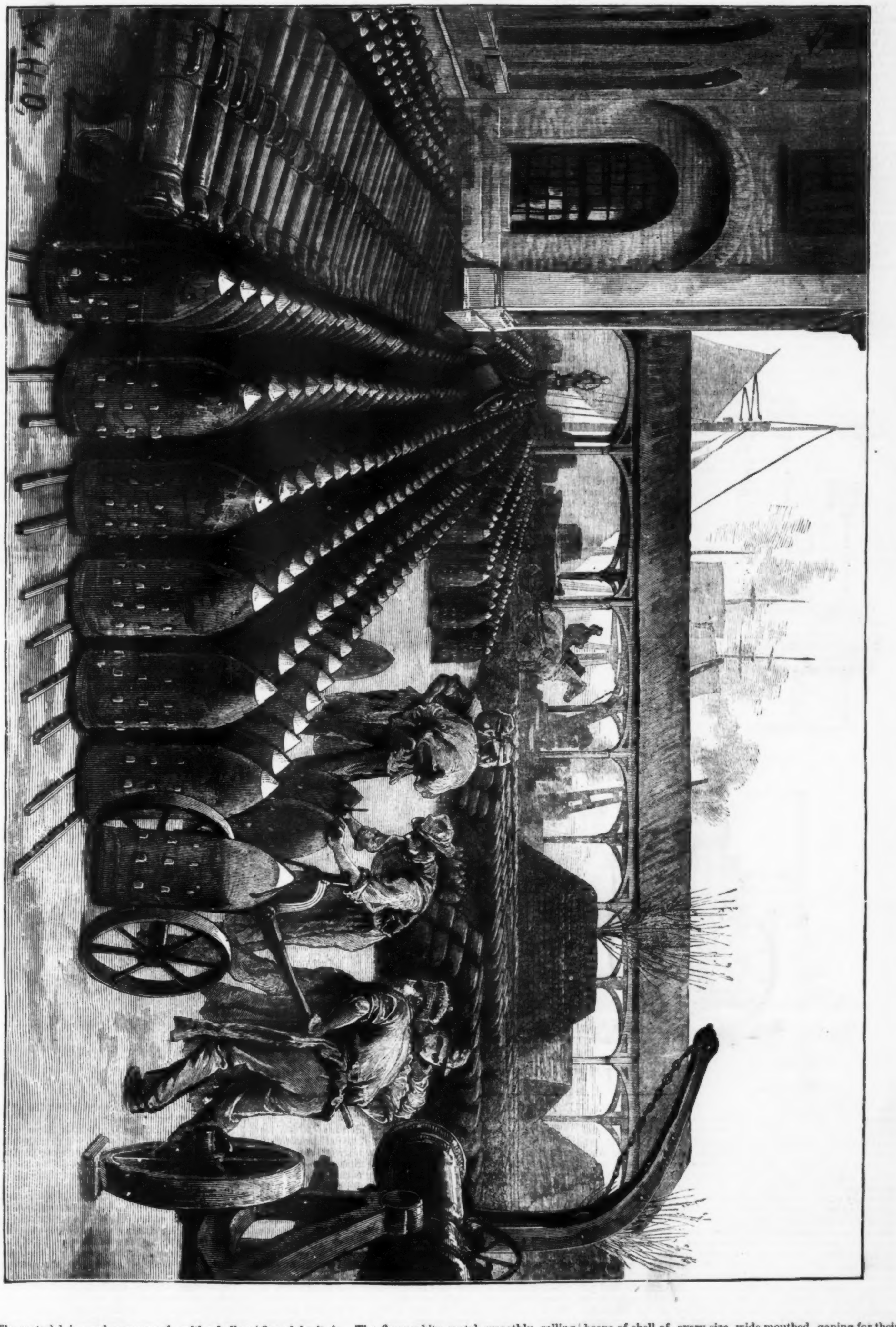
WATTS' SIMPLE AND COMPOUND SINGLE-ACTING ENGINES.

WAR MANUFACTURES IN WOOLWICH ARSENAL, ENGLAND.

THE view opposite shows the finishing of big shells to fit some of the largest ordnance for ships or permanent batteries and forts. The following is taken from an article in the *Standard*, which appeared some months ago, describing a visit to Woolwich Arsenal:—"After delivering your 'pass' at the gates, a military guide will take you into the royal laboratory, where they make bullets, and fuses, and gauges, and rockets, where they 'squirt' lead, and do 500 things with 500 lathes, which endlessly rattle and revolve around. Here the very roof seems to be in motion, so thick and so fast the bands spin round. Nine hundred men and boys are at work in the largest shed; 4,077 feet of shafts revolve with the motion of two pairs of large engines. In a small apartment at the end, hydraulic presses squeeze out solid lead like wire, and men carry it rolled upon a wheel to be cut and punched into bullets by machinery. Elsewhere they are making the clay plugs, which have superseded boxwood, to expand the bullet. Machines of great ingenuity stamp out these little cups from clay dry and powdered, which is pressed to the hardness of stone. As the bullets come rolling down, bright as a silver cataract, at each of the hundred little tables, boys press in the plugs and others carry them off to realms inaccessible, where they are fitted in the cartridge cases. Here fuses are being made, wooden and metal, time and percussion. There rockets, long rolls of iron painted red, with flanges at the base, like a ship's screw. The gas escaping at discharge works upon these wings, causing the rocket to revolve. At another series of lathes and whirling bands thin sheets of brass are being corrugated for powder cases. Everywhere is motion and bewildering activity. About 4,000 hands are employed in this branch alone, and two million cartridges are turned out per week. There is machinery set up sufficient for three million, and machines in store to furnish a quantity undetermined.

"Across the yard, in the building which was once Prince Rupert's Palace, is the pattern room or museum of the laboratory. To the right, in a fine apartment, shells of every size are ranged and neatly ticketed with their weight, character, and peculiarities. Here are the remains of the 800-pounder, which pierced three $6\frac{1}{2}$-in. plates and 10 in. of teak beyond. All the shells are displayed first whole, next cut in sections, and lastly in fragments, to show their structure. In a small room, once Prince Rupert's dining chamber, as tradition goes, are torpedoes of every kind, the long, shining Whitehead, vastly improved on the inventor's model, the stationary torpedoes like buoys, and that which travels parallel to a vessel's course, as a fishing 'otter' does. All of them are charged with gun-cotton, the Whitehead taking 500 lb. in its deadly skull. Accredited rumor has it that the sole use of this terrible invention was offered to the late Government for £15,000 and refused. It has cost us £40,000 now to obtain a share, which is likewise held by every naval power in Europe, excepting Russia.

"The large yard about these buildings was full of round shell, uncharged, of course, not many months ago. Round shell is now as ancient as bows and arrows, and the Government has found an excellent store of iron waiting to be converted to better uses. In the foundry near by we see these antique shells being cleft in two, by a hammer and a wedge, to be resmelted. And we also see them reappear in modern shape, or in the more deadly Palliser. This workshop is full day and night, with never a rest. The men here get no dinner hour. They begin to work at six A. M., and never cease till four P. M., when the shift arrives; of such importance is it to work out the furnaces when they are once heated. Probably the men do not notice their surroundings, toiling as they do in a lurid glare of burning furnaces, red-hot moulds, with twilight beyond the radius. The casting of the great Palliser shell draws most attention. By an open furnace stand the moulds, solidly fixed upright in the



WAR MANUFACTURES AT WOOLWICH ARSENAL, ENG.—700-LB. PALLISER SHELLS FOR THE 38-TON GUNS.

ground. The material is sand compressed, with a hollow cone of iron at the base. The molten metal is poured in, and that which fills the cone chills rapidly, whilst that in the sand takes a much longer time. In the result, the point becomes so hard as to pierce like steel, and the body of the shell so brittle that with the tremendous impact it explodes in a shower of fragments. This is the great but simple discovery of Major Palliser. They are making shells for the 25-ton, 35-ton, and the 80-ton guns in this foundry; and a fine sight it is. The flame-white metal smoothly rolling from the furnaces, the iron trollies carrying it about, the crane moving swiftly and silently from one to another, the smiths feeding their moulds, aflare with red light behind, dark before; the clank of iron instruments on the iron floor, the roll of heavy wheels and the clang of distant hammers—all these sights and sounds have been described many times, but they affect one scarcely the less.

"In the next building finished work is stored—rows, piles, heaps of shell of every size, wide-mouthed, gaping for their fuse, wickedly pointed, lying flat, staked in rows, suspended with chains in air. The place is full of shining machinery, always on the move. Men in wooden shoes and paper caps tinker endlessly with bars and hammers, or drag trollies full of metal white hot. The shells are every size, from the little nine-pounder of the smallest field-piece to a monster roll of iron, 4 ft. high, to fit the chamber of the 80-ton gun."

END OF THE AGE OF BRASS.

Visiting the locomotive works of the Chicago and Northwestern railway a few days ago we noticed in one department a pile about as large as a small haystack, composed of the brass castings of domes, sand boxes, steam chests, cylinders and pump chambers, boiler ornaments, etc., etc., which had been stripped from numerous engines as they came in for repairs or rebuilding. In the stalls of the round house stood numerous newly built or repaired engines with their boiler castings of lustrous Russian iron, unrelieved by a strip of shiny brass, and with all the various parts, which in the old time engine were ornamented with the dazzling sheen of the yellow metal, now painted a somber black, or covered with planished iron—plain, sober looking machines, but impressive by reason of their very plainness, looking as if they were intended for serious work, and not for playthings to dazzle the eye. It is a comparatively short time since the edict against brass ornamentation on this road went forth, but it is being rapidly enforced, and soon every one of the nearly four hundred splendid engines of this great company will show scarcely a bit of bright metal except the shining bell, surmounted, perhaps, with its brazen eagle.

The same raid upon shiny ornaments is going on upon many, probably upon most of the roads of the country, and it evidences a reform in the interest of economy which we believe to be timely and excellent. With the first volume of this journal, we commenced to raise the question whether the great expenditure of money necessary to decorate locomotives with glittering ornaments (a decoration, by the way, peculiar to American engines) and to keep them "shined up" after they were built, was advisable. Some estimates were given of the cost of this display, and with the aid of correspondents who took a similar view to ours we may believe that we contributed our mite toward bringing about the existing revolution against unnecessary show and in favor of the economy of plainness. At one time and another our columns had a good deal to say about the cost of polishing engines, and although some of our readers agree that the expense was considerable, and was unnecessary, others thought that the saving suggested was trifling, and not worth notice. And yet it was no uncommon thing to expend from fifteen hundred to twenty-five hundred dollars in superfluous ornaments, partly to please the eye of travelers and partly with the idea that the men who run the engines would take more pride in them and care for them better if they were resplendent in decorations. But we believe that the roads that have abolished the brass trimmings find that their engine men are no less attentive to their duty, and that their trains draw just as many passengers and pounds as they would if the engines were more dazzling, while there is no question of the great pecuniary saving. In addition to the very considerable economy of using iron instead of brass for finishing, the Chicago and Northwestern road has been able to dispense with about one-half of its wipers, making a saving in this item, at the West Chicago round house alone, of the wages of sixteen men, which, at $1.50 per day, is equivalent to between $8,000 and $9,000 per year, indicating an aggregate reduction of unnecessary expense for all its lines which certainly must be gratifying to its stockholders. The Chicago, Rock Island and Pacific is another company that builds its engines for use, without much regard for show, and we notice that it is already painting over the brass works on the engines of its recently acquired Keokuk and Des Moines line. It is admitted that there is something attractive and impressive about the beautiful finish and decoration of the engines of the Chicago, Burlington and Quincy road, for instance, and yet there is also an appearance of seriousness and dignity, so to speak, about the plain, black machines of the Michigan Central, as they stand alongside, which is hardly less satisfactory.—*Railway Age.*

STANDARD METERS.

By Prof. J. E. Hilgard.

On the recommendation of the National Academy of Sciences, our Government took part in the International Bureau of Weights and Measures. This bureau is established for the preparation, periodic comparison, safe-keeping, and distribution of standards, and is participated in by seventeen nations. Professor Hilgard is a member of the international committee intrusted with the charge of the bureau. The members of the committee are fourteen in number, and are elected for six years, filling their own vacancies, so as not to be subjected to transient political influence. The Government of France has ceded to the bureau an area of six acres in the park of St. Cloud. This includes the old "Pavillon de Breteuil," a good sized house, which provides accommodations for a director and two assistants. The building was once the residence of Madame Dubarry, and antiquated scandals designate it as the locality of some racy incidents in the career of the royal favorite. Star-eyed science now reigns supreme in those halls, and, as will be seen, has brought a new order of excitements in her train.

For the laboratory proper a separate building has been constructed with double walls, containing six rooms. A deep dry well, in the cellar of the building, serves for keeping the standards. At first it was thought that a crypt in a neighboring hill would meet this purpose, but that excavation could not be so easily drained, and was not on ground ceded to the bureau, and hence was not on the whole a desirable place. Last year the pavilion was made ready for the uses of the bureau. Solid piers were built for mounting the instruments. Complete apparatus was provided for cooling the rooms to zero (centigrade). Each room is jacketed with corrugated zinc. At first, cold air was tried in the spaces surrounding each room, as a means of refrigeration; this method proved a failure. Salt water trickling down the zinc was then substituted. It soon cooled the rooms to the required temperature, which can be permanently maintained. The refrigerating apparatus is actuated by steam power; the cost of maintaining a temperature of zero in one of the rooms is about fifteen dollars.

Among the instruments are four comparators; one transverse, one longitudinal, one with mirror for end measures, and one for determining the dilatation of the bars by heat. The weighing is done in vacuum, the loading and unloading of the pans and the interchange of weights being performed by mechanism, without any approach of the operator to the balances. Last year several of the instruments were mounted, and the rest had been ordered and were in process of completion. Among those which were ready for use was an instrument for measuring dilatations, the system being that of Fizeau, by observing interference bands. The income by which the bureau is supported is contributed by nations that take an interest in the undertaking. The amount called for is in proportion to the population of the nation, and Russia pays her share—a large one—although the metric system has not been adopted in that country. England takes no part, owing to an opposition which has its chief seat in the Royal Observatory.

The great ingot of platinum and iridium, of which the standard meters were formed—a mass of 250 kilogrammes—exhausted the supply of iridium in the market; but Russia kindly came to the aid of the bureau, and supplied the deficiency from a quantity that had been accumulated in the imperial treasury. It was discovered by M. St. Clair Deville that this ingot contained an impurity amounting to 1·4 per cent. of ruthenium. M. Deville offered to purify the mass at his own expense; regarding the presence of ruthenium as an accident of his laboratory. Other members of the commission took a different view of the subject, believing that this was one of the inevitable incidents of a new manufacture, in which wisdom can only be gained by experience. A great deal of discussion has been caused by this occurrence, it being alleged that the impurity was ascertained at a time when the manufacture was not very far advanced. There is a doubt as to the best course to pursue; perhaps meters containing ruthenium may be found serviceable alongside of new ones destitute of that element. We cannot yet feel assured that pure platinum and iridium will make the best alloy for the purpose, because the mechanical properties of those metals are so widely divergent. They have very different degrees of hardness. Possibly the ruthenium may have been a benefit, by filling the interstices of the alloy. The mass was rolled, drawn, and hammered till it was brought to a "pasty" or uncrystalline condition of structure. All the meters made from it have passed through white heat 200 times. No atmospheric influence is likely to affect them. Though ruthenium is itself a soft metal, it becomes so stubborn when in combination with iridium, that its presence in the meters should give no cause for fearing atmospheric corrosion.

Professor Hilgard thinks that a meter made of pure platinum would be, though soft, very useful. He is led to this opinion by the comparative accuracy of iron standards. A few years ago it was discovered that the British standards sent to this country varied from each other. They were respectively of bronze and iron; the bronze had perceptibly shortened. In four successive years, Professor Hilgard found the same amount of shortening. There is a similar bronze standard in Canada, contemporary with ours; Professor Hilgard found that standard also shortened. Owing to peculiar regulations of the authorities, the principal standard in England (the imperial standard at London) can only be examined once in twenty years; that period arrived last year, and the professor had the opportunity to compare the bronze standard yard of this country with its original fellow, which has been so carefully preserved from intrusion, and guarded against changes of temperature and disturbances of molecular equilibrium. In this comparison a difference was found, but it was less than that observed between our bronze and iron bars, in the proportion of 19 to 25. The greater shrinkage of the bronze bars that have crossed the water is attributed to their having been more exposed to variations and extremes of temperature.

The facts then are, briefly, these: Since the manufacture of these standards 25 years ago, the bronze yard (No. 11) has shortened 25-100,000ths of an inch relatively to the iron yard (No. 57), and relatively to the bronze imperial standard, it has shortened 19-100,000ths of an inch. Unless we suppose the hammered and rolled Lowmoor iron bar to have lengthened—which seems very improbable—we must concede that even the imperial standard has shortened by 6-100,000ths of an inch. This is not surprising when we consider its composition—principally copper, with a little zinc and less tin. It was scarcely to be supposed that the molecules of that alloy were in a state of equilibrium. Professor Hilgard expects that the iron standard which is here, will be sent back to England for a new comparison with the iron standard there.

LOCOMOTIVE ELECTRIC LIGHT.

PORTABLE ELECTRIC LIGHT APPARATUS.

We illustrate below a very convenient arrangement of portable electric light apparatus, which has been lately constructed by Messrs. Marshall, Sons & Co., limited, of Gainsborough, to the order of Messrs. Crompton & Fawkes, electrical engineers, Queen Victoria street, London, for hiring out to contractors and others requiring the temporary use of a powerful artificial light.

The arrangement consists of a six horse power portable engine provided with two driving pulleys having extra heavy rims, and fitted with the well-known Hartnell's automatic expansion valve gear controlled by the governors. As we have stated on former occasions, this gear gives remarkable uniformity of speed under varying loads, and is exceedingly steady and free from any tendency to pulsate or hunt, a tendency common to all governors which operate a throttle valve on the steam supply, but which is highly objectionable in an engine driving the dynamo-electric machine, as pulsations in the engine speed set up corresponding variations in the strength of the current produced, with the result that the light becomes unsteady. Moreover, the dynamo-machine itself is deteriorated by such irregular motion.

The dynamo-electric machines used in the case of the apparatus we illustrate are the continuous current A size Gramme machines of 6,000 candle power each. Indicator cards taken from the engine illustrated show that to obtain the maximum illuminating power from these machines about 3¼ to 3¾ indicated horse power is required for each machine; this of course presupposes the minimum of external resistance possible when the lamps are in circuit, as when (the lamps being placed close to the machines) the conducting cable used is short.

The machines are bolted on to a strong two-wheeled carriage or tumbril, the shafts of which also form the distance pieces for connecting it to the smokebox end of the engine;

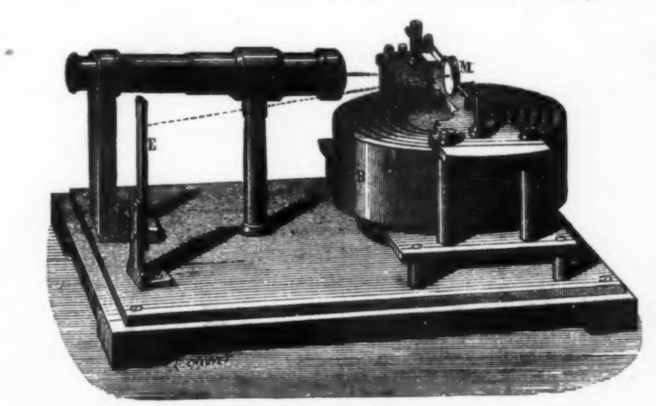
this tumbril also carries three drums having 300 yards of cable coiled on them, commutators for switching the current off and on to the lamps, or from either machine to lamp, tools, lamp-boxes, etc. The whole is covered by a light tilt cover of tarpaulin for protection from the weather. The engine can be put down, machines and lamps coupled up, and a light shown in one hour. The lamps used are modifications of the Serrin regulator, Messrs. Crompton & Fawkes having designed them to embody all the excellences of that system in a form which enables them to turn out the parts in duplicate by machine tools, and thus reduce the first cost more than one-half. These lamps we shall shortly illustrate.

The apparatus under notice has been hired out to a contractor employed in building the new works for the Stanton Iron Works Company, Nottingham, near the Midland main line. Eighty men can work conveniently and without crowding by the light of the two lamps, and they state that they can lay bricks as quickly and as well by the electric light as by daylight. The engine is used by day to drive a mortar mill, and both the contractor and his employers are well satisfied with the efficiency and economy of the light. As will be seen from the particulars we have given, the whole arrangement of this portable electric light apparatus is extremely neat and convenient.—*Engineering.*

ELECTRICITY IN AIR.—Recent experiments of M. R. Nahrwold tend to demonstrate that it is the dust in air and not the air itself which becomes electrified. When air is sifted of dust by means of glycerine, it takes only a very feeble charge. M. Nahrwold also remarked that positive electricity discharges itself more readily in air than negative, a result contrary to those of Wiedemann and Ruhlman, and we think also of Thomson. During the electric discharge, when viewed by the light of the mechanical theory of gases, would seem to show that the discharge, besides increasing the *vis viva* of the moving molecules, also increase the *vis viva* of the oscillatory motion of the ether envelopes. Different spectra got from different points in the width of the gaseous tube are therefore not to be referred only to the different temperatures of the gas, but to the amounts of electricity of which the passage causes the oscillation of these ether envelopes.

A MIRROR BAROMETER.

M. LEON TEISSERENC DE BORT has invented an aneroid mirror barometer, which is described in a recent number of *La Nature.* It is based on a method analogous to that well known since the researches of Gauss for the reading of small rotations. M. Teisserenc de Bort has sought to obtain an aneroid barometer which will give precise observations at sea,



A MIRROR BAROMETER.

especially in rough weather, when it is impossible to read the mercury barometer. The principle of this barometer is very simple. The elastic tub or box, B, carries, as in most aneroids, a metallic point, which follows its movements. In the ordinary aneroid the transformation of the vertical movement into a rotating movement necessitates either a chain or a curb, or a sort of fork which works in a spiral furrow cut in the axis which supports the needle. These various systems have the inconvenience of producing frictions; some of them are liable to dust and rust. In the mirror barometer, the transformation of the movement is obtained by the simple contact of a small palette supported on the axis of the mirror and of the point spoken of above. As the angle which the plane of the mirror may describe does not exceed 12° on each side of the vertical, it follows that the contact of the point in the palette is always precise.

As to the amplification of the movements necessary to enable us to appreciate millimeters and their fractions, this is obtained by reading with the aid of a small reticled telescope, L, the image of a graduated scale, E, which is reflected in the mirror, M. By combining the enlargement of the telescope with the distance of the scale from the mirror, we succeed in giving to the apparatus a length of less than 20 cm. by 12, which renders it quite portable. It is important to remark that the amplification of the movements of the box, which, in ordinary barometers is obtained by means of several levers, is obtained here by an optical process; it follows that the numerous frictions and the time lost in contacts are mostly eliminated. There remains only a single movement, that of the axis which bears the mirror; in the barometer figured the pivots are of steel and the cap of platinum, and in order to avoid rust, the whole is nickel-plated.

M. Teisserenc de Bort proposes to construct others, in which the axis will be mounted on rubies. This garniture will not sensibly increase the price of the apparatus. This instrument is too new to allow us to appreciate the full degree of precision which it can attain. In a trial in a captive balloon by Capt. Perrier of several aneroids as compared with the mirror, the latter showed a great sensibility, and it quickly resumed its original position on landing.

COOLING HOT JOURNALS.—Von Heeren proposes a method of cooling hot journals by a mixture of sulphur and oil or grease. The fine metal dust formed when a journal runs hot, and which strongly acts upon both journal and bearing, forms a sulphide of sulphur.

THE MIRROR OF JAPAN, AND ITS MAGIC QUALITY.*

THE lecturer commenced by referring to the vast differences between the Chinese and the Japanese nation, of which the English people, as a rule, do not seem to be aware. He instanced various points of contrast, one of the most important being the intensely Oriental secluded character of the private life of the Chinese on the one hand, and the Japanese dwelling in houses unfurnished and left wide open to the public gaze on the other. But why, he asked, in this comparative absence of nearly all that we should call furniture, does one article pertaining to the

THE JAPANESE MAGIC MIRROR.

ladies' toilet—the bronze mirror with its stand—hold so prominent a position?

This mirror of the Far East is usually circular, from three to twelve inches in diameter, made of bronze, and with a bronze handle covered with bamboo. The reflecting face is generally more or less convex, polished with a mercury amalgam; the back is gracefully ornamented with a well-executed raised design representing birds, flowers, dragons, a geometrical pattern, or some scene in Japanese mythical history. Occasionally there are also one or more Chinese characters (signifying long life, happiness, or some similar idea) of polished metal, in bold relief. The general appearance of the back of the mirror, therefore, is something like that seen in the accompanying figure.

It might at first sight be surmised that the elaborate head-dress of the ladies in Japan, combined with the painting of their faces, furnished an explanation of the prominence given to the metal mirror. But that this is not the case is easily seen from the fact that it is in the Imperial Palace, where the court ladies, still preserving the simple fashion of ancient days, merely comb back their long black tresses, and so have least need of a looking-glass, that the Japanese mirror receives the highest respect. A foreigner meets the mirror in the temples, in the hands of the street conjurer, in pictures of the infernal regions, and in the regalia of the Japanese sovereigns, and, for some time after his arrival in Japan, feels as an Oriental ignorant of biblical history might when unable to understand the constant repetition of the cross in Roman Catholic countries. But at length he hears that the mirror is part of the Japanese religion and mixed up with the "divine right of kings;" that it is the most precious of the possessions of a Japanese woman, and constitutes the most important part of the trousseau of a bride, and "the two Great Divine Palaces" at Isé, in which was deposited the first made mirror, have in the eyes of the Japanese the same importance as has the Holy Sepulcher for the Greeks and Armenians, and Mecca for the Mohammedans.

And to realize the reason of this, the stranger must learn that there is a famous ancient myth in Japan, which was recounted by the lecturer, detailing how the sun-goddess in a rage shut herself up in a rocky cave, and how the other gods, to dispel the darkness thus caused, used various artifices to entice her forth, the most successful ruse being the manufacture of the first historical mirror, in which, seeing her face, she was drawn forth by her curiosity and jealousy. He will also learn how, in the supposed creation of the Japanese empire, the sun-goddess is reputed to have handled this mirror (with the two other "god's treasures," which, together with a mirror, at present constitute the regalia of the Emperor) to her grandson, with these words, "Look upon this mirror as my spirit, keep it in the same house and on the same floor with yourself, and worship it as if you were worshiping my actual presence."

After describing many interesting points in connection with this strange mirror-worship of the Japanese, as seen in the palace and in the cottage, the lecturer went on to say that to the majority of those present the investigation of the so-called magic properties of the Japanese mirror would probably prove of yet more interest.

This magic property, which is possessed by a few rare specimens coming from the East, is as follows: If the polished surface is looked at directly, it acts like an ordinary mirror reflecting the objects in front of it, but giving, of course, no indication whatever of the raised patterns on the back; if, however, a bright light be reflected by the smooth face of the mirror on to a screen, there is seen on this screen an image formed of bright lines on a dark ground more or less perfectly representing the pattern on the back of the mirror, which is altogether hidden from the light.

When this appearance is seen for the first time it is perfectly startling, even to an educated mind, and if the source of light is sufficiently bright, as, for instance, a tropical sun, it is difficult for the observer to divest himself of the idea that the screen is not perforated with cuts, corresponding with the pattern on the back of the mirror, and illuminated from behind.

This strange phenomenon was known to both Sir David Brewster and Sir Charles Wheatstone, both of whom were of opinion that it was produced by trickery on the part of the maker. Sir David Brewster, for example, says in the *Philosophical Magazine* for December, 1832: "Like all other conjurers, the artist has tried to make the observer deceive himself. The stamped figures on the back (of the mirror) are used for this purpose. The spectrum in the luminous area is not an image of the figures on the back. The figures are a copy of the picture which the artist has drawn on the face of the mirror, and so concealed by polishing that it is invisible in the ordinary lights, and can be brought out only in the sun's rays."

Prof. Ayrton then related how he had been quite unable to find for sale in any of the shops of Japan one of these magic mirrors, which was supposed in Europe to be a standard Japanese trick, and he explained how he had at length ascertained that, with regard to this so-called magic mirror, the Japanese were the people who knew least about the subject.

But these magic mirrors were known to the Chinese from the earliest times, and one of their writers spoke about them in the ninth century of the Christian era. They call them theou-kooang-kién, which means, literally, "mirrors that let the light pass through them," this name, of course, arising from a popular error on the subject. The Roman writer, Aulus Gellius, who lived seventeen centuries ago, referred to mirrors that sometimes reflected their backs and sometimes did not. From the great antiquity of these Chinese magic mirrors, the German writer, Herr Sterne, has concluded that it is probable that the mirrors with secret signs and figures of imps on the back, which formed a portion of the stock-in-trade of the witches of the middle ages, were of Eastern manufacture. The Italian historian, Muratori, gives an account of the magic mirror found under the pillow of the Bishop of Verona, who was afterward condemned to death by Martin Della Scala, as well as of the one discovered in the house of Colla da Rienzi, and on the back of which was the word "Fiorone." But of these magic mirrors, which have played so important a part, not only in the priestcraft of China, but also in the oracles of the Greeks and Etruscans, and in the witchcraft of the middle ages, inquiry has shown that Japanese literature makes absolutely no mention.

Is it, then, that such mirrors cannot be found in Japan? Undoubtedly they cannot be bought on inquiry at the shops, but Prof. Ayrton's investigations have shown that if a careful examination with properly arranged light be made of a large number of the ordinary Japanese bronze mirrors, a few, perhaps 2 or 3 per cent., will be found showing the magic property clearly.

The lecturer then referred to the extracts he had made from a large portion of that which had been written in various languages regarding the explanation of the phenomenon. He mentioned that the earliest explanation was given by a Chinaman, Ou-tseu-hing, who lived between 1260 and 1341, and who also had the impression that the magic property of the mirror was produced by an artifice; for he wrote: "When we turn one of the mirrors with its face to the sun, and allow it to throw a reflection on a wall close by, we see the ornaments or the characters which exist in relief on the back, clearly. Now the cause of this phenomenon arises from the employment of two kinds of copper of unequal density. If, on the back of the mirror, a dragon has been produced while casting it in the mould, then an exactly similar dragon is deeply engraved on the face of the disk. Afterward the deep chisel cuts are filled up with denser copper, which is incorporated with the body of the mirror, which ought to be of finer copper, by submitting the whole to the action of fire; then the face is planed and prepared, and a thin layer of lead or of tin spread over it.*

"When a beam of sunlight is allowed to fall on a polished mirror prepared in this way, and the image is reflected on a wall, bright and dark tints are distinctly seen, the former produced by the purer copper, and the latter by the parts in which the denser copper is inlaid."

Ou-tseu-hing adds that he has seen a mirror of this kind broken into pieces, and that he has thus ascertained for himself the truth of this explanation.

In a paper communicated some years ago to the French Academy of Sciences, the well-known French writer on China, M. Stanislaus Julien, says: "Many famous philosophers have for a long time, but without success, endeavored to find out the true cause of the phenomenon which has caused certain metallic mirrors constructed in China to have acquired the name of magic mirrors. Even in the country itself where they are made, no European has up to the present time been able to obtain, either from the manufacturers or from men of letters, the information which is so full of interest to us, because the former keep it a secret, when, by chance, they possess it, and the latter generally ignore the subject altogether. I had found many times in Chinese books details regarding this kind of mirrors, but it was not of a nature to satisfy the very proper curiosity of the philosopher, because sometimes the author gave on his own responsibility an explanation that he had guessed at, and sometimes he confessed in good faith that this curious property is the result of an artifice in the manufacture, the monopoly of which certain skilled workmen reserve to themselves. One can easily understand this prudent reticence when we remember that the rare mirrors which show this phenomenon sell from ten to twenty times as dear as the rest."

The prevalent idea has been that the phenomenon of the

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* The Friday evening discourse at the Royal Institution, January 24, 1879, by Prof. W. E. Ayrton.—*Nature.*

* This probably refers to the mercury-amalgam which is used in polishing, and which Ou-tseu-hing mistook for lead or tin.

magic mirror was caused by a difference of density in the various parts of the surface, either produced intentionally or accidentally; and this, the lecturer explained, arose from two causes, first, from the common belief that the patterns on Japanese and Chinese mirrors were, like those on ordinary coins, produced by stamping; the other, because the distinguished European philosophers who had examined into the question had investigated with considerable success, experimentally, how such mirrors might be made, but they had not, the lecturer thought, directed their attention to the examination of the question—How was the phenomenon in these rare Eastern mirrors actually produced?—obviously a very different question.

Prof. Ayrton mentioned that he and Prof. Perry were led to take up the investigation from a very remarkable fact pointed out by Prof. Atkinson, of Japan, viz., that a scratch with a blunt iron nail on the back of one of these magic mirrors, although it produced no mark on the face of the mirror which could be seen by direct vision, nevertheless became visible as a bright line on the screen when a beam of sunlight was reflected from the polished face of the mirror. The lecturer mentioned that after trying several experiments with polarized light, etc., Prof. Perry and himself availed themselves of a very simple method of investigation, but one which had apparently not suggested itself to previous observers. On one occasion, when some of their students were using lenses to endeavor to make the exhibition of the phenomenon more striking, it occurred to them that the employment of beams of light of different degrees of convergence or divergence would furnish a test for deciding the cause of the whole action. For while, if the phenomenon were due to the molecular differences in the surface—the commonly received opinion—the effect would be practically independent of the amount of convergence of the beam of light; on the other hand, if it by any chance were due to portions of the reflecting surface being less convex than the remainder, a complex inversion of the phenomenon might be expected to occur, if the experiment, instead of being tried in ordinary sunlight, were made under certain conditions in a converging beam—that is, the thicker portions of the mirror might be expected to appear darker instead of lighter than the remainder.

[Experiments were then shown of the image cast on the screen: (1) when a divergent beam of light fell on the mirror, (2) when the beam was parallel, (3) when the beam was convergent; and it was seen (1) the pattern appeared as bright on a dark ground, (3) the pattern was invisible, (3) the pattern appeared as dark on a light ground.]

Again, by allowing a parallel beam of light to fall on it, and interposing a double convex lens between the mirror and the screen, we can make the image show the pattern either as bright on a dark ground, or as dark on a bright ground, or not at all, merely by causing the screen to be: 1st, nearer the lens than the conjugate focus of the mirror; 2d, farther than the conjugate focus; 3d, at the conjugate focus. [This experiment was here shown.] Now it can easily be proved by simple geometrical optics that each of these effects would be produced if the thicker parts of the mirror were a little less convex than the remainder. [This was explained by various geometrical diagrams.] And lastly, if the phenomenon was, as the previous experiment would lead us to conclude, due not to unequal reflecting power of the different portions of the surface of the mirror, but to minute inequalities on the surface, in consequence of which there is more scattering power of the rays of light falling on one portion than on another, then, since rays of light, making very small angles with one another, do not separate perceptibly until they have gone some distance, it follows that if the screen be held very near to the mirror, the apparent reflection of the back, the magical property, in fact, ought to become invisible. And this also, it was shown, was exactly what happened when the screen was made almost to touch the polished surface.

The lecturer then proceeded to explain why a divergent beam emitted by a bright luminous point at some fifteen feet distance from the mirror gave the best effects.

We have therefore strong reasons for favoring the "inequality of curvature" theory. In order, however, to make the explanation quite certain, the lecturer said he had made a small concavity and a small convexity on the face of one of the mirrors by hammering with a blunt tool, carefully protected with a soft cushion to avoid scratching the polished surface, and he showed by experiment that the concavity reflected a bright image and the convexity a dark one, when the pattern on the back appeared bright, but when the light was so arranged that the pattern appeared as dark on a bright ground, it was the convexity which appeared as the bright spot and the concavity as the dark one.

Guided by all that precedes, we are led to the undoubted conclusion that the whole action of the magic mirror arises from the thicker portions being flatter than the remaining convex surface, and even being sometimes actually concave. But, in spite of this irresistible conclusion forced on us by the experiments previously mentioned, it must be admitted that it seems extraordinary how such small inequalities in the surface of the mirror, so small, in fact, that the eye quite fails to detect them, can, even with a proper arrangement of the light, produce on the screen an image of the pattern on the back as sharp and clear as is seen with a good specimen of the magic mirror.

The next question arises, Why is there this difference in the curvature of the different portions of the surface? The experience that Prof. Ayrton had gained from an examination of a large number of Japanese mirrors supplied, in part at any rate, the answer to the question. No thick mirror reflects the pattern on the back, not one of the many beautiful mirrors exhibited at the National Exhibition of Japan in 1877, and which the lecturer was so fortunate as to be able to experiment with in a darkened room with a bright luminous point at some twelve feet distance, showed the phenomenon in the slightest degree; some good old mirrors in the museum of the Imperial College of Engineering, and which belonged to the family of the late Emperor, the Shogun, of Japan, failed to reflect any trace of a design, and some old round mirrors without handles, which he had also tried, were (with the exception of one which was immensely prized, and brought to him wrapped in five distinct silk cases, and the heirloom of the family of a nobleman) equally successful.

Again, it is not that the pattern is less clearly executed on the backs of these choice mirrors, since the better the mirror the finer and bolder is the pattern; but what is especially noticeable is that every one of these mirrors is, as a whole, far thicker than an ordinary Japanese mirror, and its surface is much less convex.

This naturally led him to inquire how are Japanese mirrors made convex? Are they cast so, or do they acquire this shape from some subsequent process? His search through all the literature at his disposal—European, Japanese, Chinese—on the subject of mirrors failed to elicit the slightest hint; he was therefore compelled to perform the somewhat difficult task of obtaining information from the Japanese workmen themselves. Eventually he ascertained that, while practically all Japanese mirrors were convex, the surface of each half of the mould was flat, and that the curvature was given to the mirror after casting in the following way: The rough mirror is first scraped approximately smooth with a hand-scraping tool, and as this would remove any small amount of convexity had such been imparted to it in casting, it is useless to make the mould slightly convex. If, however, a convex or concave mirror of small radius is required, then the surface of the mould is made concave or convex. On the other hand, to produce the small amount of convexity which is possessed by ordinary Japanese mirrors, the following method is employed, if the mirror is thin, and it is with thin mirrors that we have especially to deal, since it is only in these mirrors that the apparent reflection of the back is observed. The mirror is placed face uppermost on a wooden board, and then scraped, or rather scratched, with a rounded iron rod about a third of an inch in diameter and a foot long, called a megebo, "distorting rod," so that a series of small parallel scratches is produced, which causes the face of the mirror to become convex in the direction at right angles to the scratches, but to remain straight parallel to the scratches, in fact, it becomes very slightly cylindrical, the axis of the cylinder being parallel to the scratches. This effect is very clearly seen by applying a straight edge in different ways to the face of an unpolished mirror which has received a single set of scratches only. A series of scratches is next made with the megebo in the direction at right angles to the former, a third set intermediate between the two former, and so on, the mirror each time becoming slightly cylindrical, the axis of the cylinder in each case being parallel to the line of scratches, so that eventually the mirror becomes generally convex. Some workmen prefer to make the scratches with the megebo in the form of small spirals, others in the form of large spirals, but the general principle of the method employed with their mirrors appears to be always the same—the face of the mirror is scratched with a blunted piece of iron, and becomes slightly convex, the back, therefore, becoming concave.

[Mirrors were here exhibited, one with its surface flat, although somewhat rough, just as it came from the mould after casting; a second that had received one set of parallel scratches with the megebo, and which, by means of a straight edge, was shown to be slightly cylindrical; and a third on the face of which the operation of scratching had been completed, and which was therefore slightly convex.]

After the operation with the "distorting rod" the mirror is very slightly scraped with a hand-scraping tool to remove the scratches, and to cause the face to present a smooth surface for the subsequent polishing.

In the case of thick mirrors the convexity is first made by cutting with a knife and the distorting rod applied afterward. But in connection with this cutting process of thick mirrors, there is one very interesting point. If the maker finds, on applying from time to time the face of the mirror to a hard clay concave pattern, and turning it round under a little pressure, that a portion of the surface has not been in contact with the pattern, in other words, that he has cut away this portion too much, then he rubs this spot round and round with the megebo until he has restored the required degree of convexity. Here again, then, scratching on the surface produces convexity.

Now, why does the scraping of the "distorting rod" across the face of the mirror leave it convex? During the operation it is visibly concave. The metal must receive, then, a kind of "buckle," and spring back again so as to become convex when the pressure of the rod is removed. It might in such a case reasonably be expected that the thicker parts of the mirror would yield less to the pressure of the rod than the thinner, and so would be made less convex, or even they might not spring back, on the withdrawal of the rod, and so remain actually concave. Again, since we find that scraping the face of the mirror is the way in which it is made convex, and the back therefore concave, we might conclude that a deep scratch on the back would make the back convex and the face slightly concave. Such a concavity would, as we have proved, explain the phenomenon of the bright line appearing in reflection of sunlight on the screen, which was observed by Prof. Atkinson to correspond with the scratch on the back.

After the scratches produced by the megebo are removed the mirror is polished with whetstones and then with charcoal. The face now becomes fairly smooth, but it still generally contains some few cavities; these the maker fills up from a stock of copper balls, of various sizes, which he has at hand. (It was probably the presence of these bits of copper that led Ou-tseu-hing to believe that the explanation of the cause of the magic mirrors was the inlaying of different metals.) The face of the mirror is finally rubbed over with a mercury amalgam, containing 50 per cent. of tin, by means of a small straw brush or the hand.

The lecturer then referred to the various metal mixtures employed by the Japanese in making their mirrors, the best being composed of 75 per cent. of copper, 23 of tin, and 2 per cent, of a natural sulphide of lead and antimony.

Although the Japanese have paid no attention to the magic mirror, which has created such interest in Europe, they have, in connection with their priestcraft, employed mirrors on the surface of which, if looked at obliquely, could be seen the faces of saints, but which were not in any way connected with the pattern on the back of the mirror. [Photographs of such mirrors were projected on to the screen.] The lecturer also exhibited two mirrors of this kind which he had had made in consequence of the belief expressed by one of the Japanese mirror-makers that the phenomenon of the so-called magic mirrors was produced by chemical action on the surface. But the result of the experiment had been that if the face of a mirror which had been chemically acted on was polished until every trace of the marks disappeared for direct or oblique vision, then they also disappeared in the image produced by reflecting a beam of light on to a screen, and consequently that it did not seem possible, as far as his experiments had gone, to produce, by means of chemical action on the surface, a mirror fulfilling all the conditions of the magic mirror.

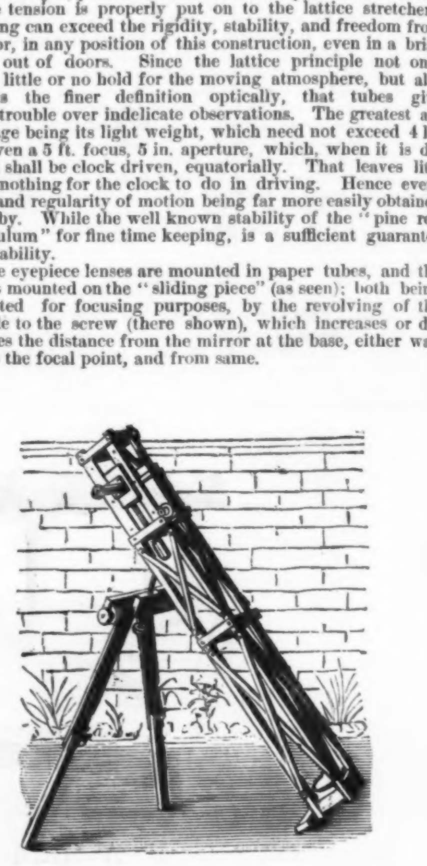
He concluded by saying: "It appears, then, contrary to what is commonly believed, that the magic of the Eastern mirror results from no subtle trick on the part of the maker, from no inlaying of other metals or hardening of portions by stamping, but merely arises from the natural property possessed by certain thin bronze of buckling under a bending stress, so as to remain strained in the opposite directions after the stress is removed. And this stress is applied partly by the distorting rod and partly by the subsequent polishing, which, in an exactly similar way, tends to make the thinner parts more convex than the thicker."

NEWTONIAN TELESCOPE FOR AMATEURS.

Seeing a constant stream of querists in these columns seeking home telescopic means, the writer has designed the illustration below to meet the wants of the same. There is nothing that need deter the humblest hand, with a screw-driver and other simple tools, to essay the construction of such, for a few shillings cost. Its arrangement is allied to that of the altitude-azimuth class of mounting, but possesses, beyond that, a pseudo-equatorial action, by which an object is kept in the field by one motion instead of by two. As in the perfect form of altitude-azimuth mountings, of which one of our Royal Observatory employes has said, in his well-known work on "Practical Uses of Instruments," "that this latter is the most useful of all portable instruments," and therefore recommends itself especially to the (starting) amateur astronomy student for his home work.

The tube or frame of this telescope is constructed of four pine laths, $\frac{7}{8}$ in. square, attached by $1\frac{1}{4}$ in. wood screws and copper birs, to the mirror supporting base, as seen on the ground, composed of four $\frac{3}{8}$ in. layers of glued and riveted (across the grain) pine. The same is then trussed and tension stretched, on the well-known lattice girder modern bridge building principles, by $\frac{3}{4}$ in. × $\frac{1}{4}$ in. pine laths, also attached by $1\frac{1}{4}$ in. wood screws and copper birs. When, if the tension is properly put on to the lattice stretchers, nothing can exceed the rigidity, stability, and freedom from tremor, in any position of this construction, even in a brisk wind out of doors. Since the lattice principle not only gives little or no hold for the moving atmosphere, but also allows the finer definition optically, that tubes give such trouble over indelicate observations. The greatest advantage being its light weight, which need not exceed 4 lb. for even a 5 ft. focus, 5 in. aperture, which, when it is decided shall be clock driven, equatorially. That leaves literally nothing for the clock to do in driving. Hence evenness and regularity of motion being far more easily obtained thereby. While the well known stability of the "pine rod pendulum" for fine time keeping, is a sufficient guarantee for stability.

The eyepiece lenses are mounted in paper tubes, and the flat is mounted on the "sliding piece" (as seen); both being actuated for focusing purposes, by the revolving of the handle to the screw (there shown), which increases or decreases the distance from the mirror at the base, either way up to the focal point, and from same.



NEWTONIAN TELESCOPE FOR AMATEURS.

The finder, seen attached above the eyepiece, is a dumpy, being a crossed $1\frac{1}{4}$ in. lens, of short focus. Behind the field lens of the eyepiece thereof is a plane mirror, set at an angle, so as to throw the field out at the side, through the eyelens, parallel with the eyepiece of the telescope, and close alongside (as shown). This has been found to be a great comfort, when passing from star to star of a constellation, with high powers, there being no necessity to leave the observing stool, and crane the neck into an impossible position in order to use the finder. And this especially so when observing in the zenith. That only position of our climatic sky in which, as a rule, we can alone observe.

The supporting mechanism (engraved) has telescopic legs, jointed by a friction nut-clamp to the transverse horizontal (as shown) cross-head screw piece, permitting that to oscillate on its center (being so attached as to clamp at any angle), to suit the motion of any given object moving equatorially for the space of an hour or so. By the single motion of that one screw only, as that carries the sliding piece (shown in the center) with the declination screw carrying the telescope on its point through this motion, due to the angle of the clamped cross head piece. This motion is not equatorially perfect, but is so sufficiently so that for purposes not of exact astronomical observation and computation; but the pleasure in the home of the first steps to higher astronomy ends, where it serves to keep the object centrally in the field of the highest power with one motion instead of two, as in the usual altitude-azimuth mounting.

For the purposes of sketching, lunar work, etc., this pseudo-equatorial screw has been driven by a clepsydra, or water-clock (preferably used with oil). This I will fully describe hereafter, and all its bearings, where it relieves the economic student of the cost of his expensive driving-clock, and realizes for a few pence a far more handy and perfect driving power. It has produced all the comfort that could be desired for lengthened periods of sketching, as far as keeping the object in the center of the eyepiece field could be desired. As the engraving stands, the whole is arranged for observation due south, where objects move all but horizontally.

This form of construction gives the utmost freedom from tremor, and is lightness itself for moving in and out of doors, and when done with does not sprawl all over a room, but may be stood up in any corner out of the way anywhere.—*A. J. S., in English Mechanic.*

AN ENGLISH CONVALESCENT HOME.

ON Easter Monday their Royal Highnesses the Prince and Princess of Wales visited the Norfolk sea-coast village or little town of Hunstanton, eight miles from their residence at Sandringham, to open the new Convalescent Home for the sick poor of the Eastern Counties. The building, of which we give an illustration, stands on the brow of a hill above the town, and, including some ground recently purchased to prevent interference with the sea view, occupies some two and a half acres. This additional plot of land has not yet come into possession, and it had been covered by an enterprising speculator with a stand for excursionists desirous to witness the opening of the Home. The Home was erected and furnished for £4,000, of which the Earl of Leicester, who is Lord Lieutenant of the county and president of the institution, has munificently given the fourth part. It is in early English domestic style, the same which was splendidly represented in the Rue des Nations last year at the Paris Exhibition. It was built by Mr. Southgate from the designs of Mr. Hutchinson, of Huntingdon, Mr. Colman, of the latter place, acting as clerk of the works. Mr. Kempton had decorated it for the day with flags. The material is the warm, rich carr-stone, from the Le Strange estate at Snettisham, of which the houses at Hunstanton are generally built. It is, in this case, relieved with white and red bricks and ordinary stone from Ketton. There are three gables with attic windows in the high-pitched slated roof, but the main floors are only two in number—the first floor and that on the ground. The day-rooms and the beds for cripples are below, the dormitories are above. One wing is devoted to men and the other to women. In the center is the dining-room, which trends out to the rear and forms the connecting link between the front or main building and the range of

THE CONVALESCENT HOME, HUNSTANTON, ENG.

kitchens and offices at the back, parallel to the front building. Thus the ground-plan of the house forms the letter H. The main building is 110 ft. in length, 42 ft. in depth, and 44 ft. high. The rooms in the main building were named after the towns which have contributed the furniture. At the men's end is "Cambridge," a fine, bright room, decorated with prints of the Gate of Honor at Caius (this college gave £25 to the funds), the backs of the colleges, and the view from Castle-hill. Permission, however, is granted to call this room the Albert Edward, and to name the women's day-room, which is now known as "Wisbech," the Alexandra. The Prince of Wales has subscribed liberally to the funds of the Home by annual and special donations. The "Wisbech" room contains several comfortable chairs of a pattern like that which the Princess of Wales had brought specially from London for an invalid on her husband's estate. The towns of March, in Cambridgeshire, Peterborough, and Bedford gave the furniture of the sleeping-rooms. The oak dining-table and birchen chairs of the common dining-room were provided by Hunstanton. Mr. Mason, of Stamford, presented the kitchen fittings, and the Home has profited by many other gifts in kind. The forty beds, for instance, were given in answer to a special appeal by forty ladies of the several places mentioned. The Princess of Wales was the first to respond to this appeal, and so many ladies followed suit that, with their permission, their gifts were converted to other uses. The sketches which decorate the "Wisbech" room were given by Mr. E. N. Rolfe, one of the family which is said to preserve in this part of England the blood and the memory of the Princess Pocahontas. There are convenient buttery-hatches between the kitchen and the dining-room, gas, water, and ventilation throughout, and there is a coach-house with stabling, in which, says the matron, they hope some day to keep a pony-chaise, "to give the patients a treat round." An orchard and an herb garden are being formed in the grounds. A careful selection has been made of trees and shrubs, which Mr. Bird, of Downham Market, an authority upon these matters, hopes to see flourishing even at a spot so close to the sea. There are no patients at present in the Home, but subscribers, and clergymen whose harvest offertories have been sent to the fund, will nominate poor people for admission. The patients pay 5s. a week, and the cost to the Home has hitherto been 19s. 7d., on the average, for each patient.—*Illustrated London News.*

COMMON DEFECTS IN HOUSE DRAINS.*

By ELIOT C. CLARKE, C.E., Principal Assistant Engineer in Charge of Improved Sewerage Work, Boston, Mass.

THE purpose of this paper is to state what are the common defects in house drains, and to show the usual forms and conditions of such drains as they exist in our cities and towns to-day. The statement is chiefly based on observations made in Boston while constructing intercepting sewers; but it is assumed that examinations in other cities and towns of the Commonwealth would reveal a condition certainly no better, and probably worse. Some testimony will be offered from those whose occupation has given them opportunities for observation; and, while it is not intended to cite exceptional cases of defective arrangement or construction, a few characteristic examples will be given, such as investigation would prove to be very common.

What are the essential conditions of an efficient house drain, one or more of which must be violated to constitute a defect?

Briefly stated, they are, that the drain must be of size and shape to concentrate its flow, smooth inside, suitably inclined, tight, properly connected with the house pipes and sewer, strong and durable in material. It is of great importance that the portion of the drain within the house should be always in such a position as to admit of ready inspection at any time; it *should be in sight*, † and not concealed. Let us see what proportion of Boston drains reasonably fulfill these conditions.

Existence is perhaps the most essential condition of a drain; and, by a Hibernicism, non-existence may be termed its most serious defect. Naturally non-existence was not observed in digging for the intercepting sewers, but there is sufficient evidence that it is not unknown.

The writer has seen a case where a drain pipe from a dwelling ran through the walls, and there ended; several similar cases have been reported to him; and another, where a block of six expensive houses, occupied for months with all the customary apparatus in the way of plumbing and waste pipes in full operation, had no drains beyond the walls to the street sewer. Such cases are rare, and generally reveal themselves quickly; but it is more common to find drains which are so solidly filled with earth, grease, and other matter, as to exist only in name, and which, for any good they accomplish, might just as well not exist at all. One, examined by the writer some months since, had apparently had nothing through it for years, the whole waste from the soil pipe having accumulated beneath the cellar floor. The same state of things was lately found to exist below the Rockland Bank Building in Boston. A case has been mentioned to the writer where it is thought that three deaths can be directly traced to the stoppage of a drain which was so clogged as not to act. Almost every one who has been led into this line of inquiry has some similar instance to relate, and evidence could be multiplied indefinitely. Of the house drains crossing the intercepting sewer trench, during its construction last season, fully twenty-five per cent were almost or entirely choked with sludge.

An example of *semi*-existence, observed while digging for the sewer in Charles street, is worth noting, as showing the intelligent judgment sometimes exercised in doing this kind of work. It will be understood by referring to the sketch (Fig. 1). The drain was one for surface water; and the drain layer, in digging from the house toward the sewer, came upon a log lying across his trench, and here stopped short, chopped a hole in the log, found it hollow, and connected his drain to it without going further. It is true, the log led to no outlet, but then it saved trouble—to the drain layer.

As to the question of size of drains, it was found that of 113 observed while building sewers the past year—

11	were about	4	inches in diameter.	
4	"	"	5	"
21	"	"	5	"
5	"	"	7	"
27	"	"	8	"
8	"	"	9	"
11	"	"	10	"
26	"	"	12	" or over "

The next sketch (Fig. 2) illustrates the wide range of this diversity. Most of them drained single dwellings similarly situated; and if the small ones were large enough the others must have been unnecessarily large, and *vice versa*.

But what is the proper size?

Probably nine engineers out of ten would answer, "By no means larger than 6 inches;" and nine drain-layers out of ten would now say, "Never smaller than 8 inches." The former argue that the drain need only be large enough to pass through it all that it can reasonably be expected to carry, and that anything beyond this tends to make the ordinary flow spread thinly over a broad bottom, without sufficient depth to carry solid matters along with it. The latter reply, that, in fact, a drain never does receive only what can reasonably be expected; and that, the larger the drain, the more storage-room for the unreasonable accumulations of clothing, tin and glass ware, dead animals, etc., usually found in it. "In practice," say they, "large drains take longer to choke up than small ones, and are therefore better."

Their facts are correct, but their conclusions may be doubted. In building a drain, the object should be to prevent the *beginning* of a deposit; and this is much easier in a small drain than in a large one, as will be understood from Fig. 3, where an equal quantity of water is supposed to be flowing in a 4 inch and a 12 inch drain. It might be thought (by one who thought at all about such matters) that the discharge of a great volume of water, as from a bathtub, would tend to scour out and clean a drain. So it might a very small one. But in such a structure as our sketch represents, with a flat bottom 12 inches wide, the stream caused by such a discharge would probably meander over the bottom of the drain, and be nowhere over a quarter of an inch deep. Let a deposit once begin, and subsequent accretions as surely coke a large drain as a small one, only it takes longer to do it.

* From the Tenth Annual Report of the State Board of Health of Massachusetts. The cuts are used by permission of the Secretary of the Board, and furnished by the courtesy of Messrs. Rand, Avery & Co., Boston, Printers to the Commonwealth.

† The same rule applies, of course, to soil pipes, although that part of the subject does not come within the scope of the present inquiry.

And it may even be questioned whether it is an advantage to be able to use for an additional year a drain nearly full of putrescent filth, or whether it is not better to have the evil disclosed and remedied as soon as possible. It may safely be said that three quarters at least of the house drains in Boston are too large, because, even if some of them perform efficient service, small ones would do as well, and be less liable to get out of order.

In respect to form, there is almost as much diversity as there is in size. Figs. 4 to 10 give the more common shapes.

The first three must be condemned at once, on account of their flat bottoms. The water passing through them spreads out into a thin sheet, which does not readily wash along solid matters. Floating matters also tend to stick in the angular corners more than they would on rounded surfaces. That this is so, is shown by the record. Of the 113 house drains whose condition was noted, 45 were constructed with flat bottoms; and of these 26 were choked, or nearly so, with sludge; 19 were reasonably clean. Of the remaining 68, which had rounding bottoms, 12 were full, or partly so, of sludge; 56 were reasonably clean. The common appearance of these flat bottomed drains, as they were uncovered, is shown in Figs. 11, 12, and 13. Fig. 13 represents the condition of a drain, now disused, which came from the City Hospital grounds.

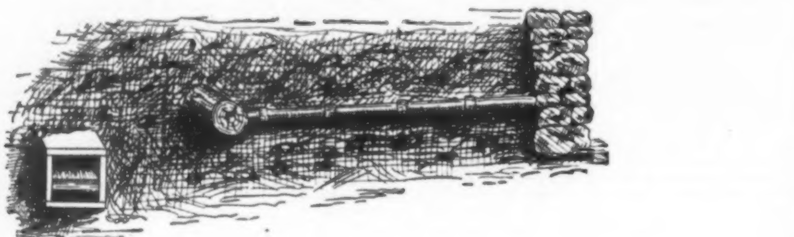


FIG. 1

The shapes shown in Figs. 7, 8, 9, and 10 are unobjectionable, although, in fact, these drains were often too large, and had other defects. Fig. 8 is a kind of construction which was in vogue twenty-five years ago; and except for liability to open joints, its angular bottom, and its size, is passably good. Our facts seem to show that forty per cent of the Boston house drains are defective in shape.

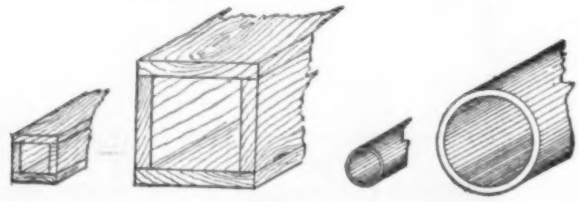
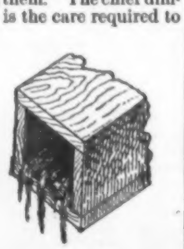


FIG. 2

A drain should be smooth, so as to afford no prominences for solid particles to lodge upon. Planed wood, slate, and brick are smooth enough. In use they soon become covered with a film of slime that makes them very slippery. Unplaned wood, which until recently has been somewhat used, is apt to be rough, and to have splinters pointing against the flow, which catch solids moving upon them. The chief difficulty in making a brick drain smooth is the care required to see that no mortar is left projecting into the drain. Fig. 14 shows the manner in which such work is often finished.



It is possible to strike each joint of the lower half of the drain so as to leave a reasonably smooth surface; but a difficulty harder to avoid is caused by portions of the mortar uniting the arch bricks, falling when the supporting centers are removed. These lumps of cement, indicated in the sketch, adhere to the bottom, and, unless carefully scraped off, harden, and form serious obstructions to the flow of sewage.

Pipe drains, whether cement, clay, or iron, are smoother than those of brick. Glazed clay pipes are especially smooth. In these, however, it is very common to find the mortar uniting the several sections of pipe projecting into the interior, forming a series of little dams which obstruct the flow. Fig. 15 illustrates this. This can be avoided by carefully cleaning the interior of each pipe, after laying it, with a swab or hoe; a simple precaution, but often neglected by a careless drain layer. It will not be an exaggeration to say that three quarters of existing drains are defective as to their smoothness.

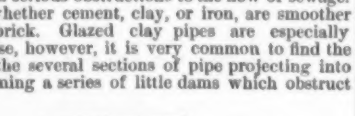


FIG. 4

The best rule in practice for the inclination of a house drain is to give it as much pitch as is possible; and in few cases is less than one half inch to the foot safe. A great many drains are faulty in this respect. The actual inclination of drains crossing the trench of the intercepting sewer the past year was not taken; but, of the 113 met with, 9 are recorded as level, and 14 as pitching the wrong way, that is, toward the house. One of these, coming from a public school building, was about 7 inches lower at the street curbstone than at the sewer. The condition of such a drain is shown in Fig. 16.

The water stands in the depressed portion of the drain to the height of its connection with the sewer; and, having little motion deposits are apt to occur. In the case referred to, it is but fair to say that the school drain was clean so far as seen. Very possibly an abundant use of water or recent heavy rains had scoured out any deposit that may have taken place. It is probable that most of this inclination in the wrong direction occurs in the street near the sewer. The drain layer frequently begins to put in his drain simply with reference to the house, without inquiring what is the elevation of the sewer into which it is to empty. He digs his trench towards the street, and lays his drain on a slope which he judges by his eye to be sufficient. This in itself is a deceptive matter, as a trench generally seems to slope down towards the observer. When the sewer is reached, it is found to be higher than the portion of drain already laid. What is to be done? It is not the drain layer's fault, that the sewer is too high; he cannot take the trouble to dig up his pipe again; it is only a few inches any way; and the pipe is run up and connected, the trench back filled, and, "out of sight, out of mind."

It was stated that one of the essentials of an efficient house drain is that it shall be tight. Mr. Ernest Bowditch has called the writer's attention to a condition in which, at first sight, a leaky drain might appear better than a tight one. He says, "It is sometimes noticed, when plumbing is from twenty to twenty-five years old, and where all the drains outside the cellar walls are of open stone (technically French drains), the soil pipe not being ventilated, that there is no perceptible leakage of sewer gas into the house. It is reasonable to suppose in these cases that the gas generated outside the house works up through the soil, rather than force the traps in the house. The modern method of tight drains and cesspools tends to drive all gases into the house. It is frequently more important therefore, that recent plumbing should be ventilated, than that of older date."

Both tight and open drains tend to produce evils; but those arising from a tight drain can be obviated by proper ventilation of the house pipes, while the evils from leaky ones are irremediable. Therefore, we say, drains should be tight, that sewer gas (or, what is worse, matters capable of producing sewer gas during a long decomposition) may not escape; and also that the water may not leak out, leaving the solid contents of the drain stranded.

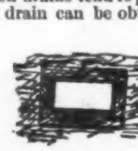


FIG. 5.

This want of tightness is the commonest defect of all, and probably three quarters of the annoyance from drains is due to it. In the annual report of the Boston City Board of Health for the year ending April 30, 1878, is given the result of examination of 351 house drains in different sections of the city. Of these, 193, or 55 per cent, are reported as defective; and in nine cases out of ten the defect consisted in the drain not being tight. This defect, more than others, affects the better kind of houses.

Mr. Theodore Clark, who has had experience with this class of dwellings, speaks thus of earthenware and cement drain pipes: "These, I think, rarely remain tight many years. Even where the drains are laid with the greatest care, I have observed that water will often, in course of time, make its way out around the joints between the pipe and the ring of cement. When broken it is found that the cement has taken a perfect mould of the pipe; but either from some greasiness, or possibly a little dust on the pipe at the time of laying, it has failed to adhere, and water has ultimately forced its way through. An accumulation of water caused by an obstruction in the pipes will often search out such places, which must have previously allowed gas to pass freely. Another very frequent source of trouble is the settling of the ground under and around the drain pipes. In houses with drains originally in perfect condition, their joints will frequently, in a year or two, be found to be separated, the pipes cracked, or the branches settled away from the soil pipes which enter them. In either case the drainage saturates the ground about the defective places with matter whose effluvium will penetrate even concrete.

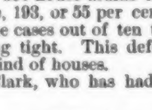


FIG. 6

"In my experience, defects of this kind are far more common than leaks in iron soil pipes, imperfect traps, or other defects attributable to the plumber; and the earthen drain-pipe should generally be first examined in searching for the cause of unpleasant smells in any part of the house, as effluvia originating in the cellar often find their way through furnace pipes and behind furrings to the remotest corners of a building."

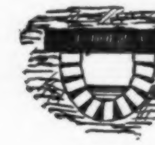


FIG. 7

In this connection may be cited several cases recently reported, in each of which a smell was noticed whose source it seemed impossible to locate, until at last a leak was discovered in the drain directly communicating with the cold air supply pipe of the furnace, which latter, of course, acted as a distributer of the gas through the entire house. A similar leak into the air duct of the Boston City Hospital proved a source of serious illness, and probably of increased mortality, among the surgical patients, until remedied in course of the various improvements introduced by Dr. Cowles.

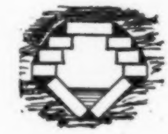


FIG. 8

Leaky drains are due to a variety of causes. In a brick drain the joints between the bricks may not be solidly filled with mortar, the mortar may not adhere to the bricks (a common result of not wetting the latter before laying), the bricks themselves may be shaky or rotten, or the structure as a whole may be broken by unequal settling. In some drains no attempt is made to have tight joints. A kind much built some years ago, and of which many examples remain, is shown in Fig. 17. In this the bottom is made of roofing slates placed side by side, or sometimes overlapping, but never with anything to prevent water percolating through the joints into the soil below. Fig. 17 reversed, with plank below and slates above, would resemble more than half the drains on Beacon Hill as they were originally made, and still exist. A plank drain may leak through open joints, variously caused, through knot and nail holes, and by the rotting of the wood where it is not constantly wet. A pipe drain may leak from bad joints, from flaws in the pipe itself, or because it has been broken. The breakage is generally due to unequal settling, sometimes to defective pipes, and occasionally to improper methods of laying them. The sections are sometimes carelessly or ignorantly laid on the bottom of the trench, resting merely upon their flanges as shown in Fig. 18, instead of upon their entire lengths, with depressions dug out for the flanges, as in Fig. 19.

FIG. 9

FIG. 10

In the former case, unless the dirt be rammed back beneath the pipe with unusual care, the pipe acts as a beam resting on supports three feet apart, and is liable to be broken by the superincumbent earth, or by any shock, as of a body falling or a wagon jolting over it.

As the greater proportion of leaks are caused by defective joints, it follows that a brick drain with joints every inch or two is more liable to this defect than a clay or cement pipe with joints two or three feet apart, and that iron pipe in five foot lengths is less liable to it. A place where a leak frequently occurs, especially in a house built on made land, is where the drain passes through the cellar wall. If the foundation wall is supported, and the ground on either side settles, a condition of things is produced shown in Fig. 20.

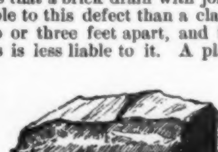


FIG. 11

A drain may exist in such a state for months, or longer,

without detection. The water follows the wall, perhaps into neighboring houses, saturates the ground in the vicinity, and finally finds an outlet through some pervious stratum or into some well. If the cellar be concreted, little moisture may be apparent—an ill-defined odor to which the family become accustomed, and about which visitors feel a delicacy of speaking, being the only suggestion of trouble—until finally, perhaps, may come some "unaccountable" sickness, or "mysterious visitation of Providence." Mr. W. H. Bradley,

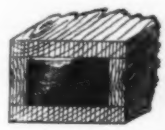


FIG. 12

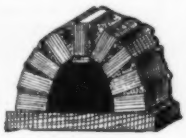


FIG. 13

Superintendent of Boston Sewers, spoke thus of this matter three years ago, in a communication to the city government: "The number of drains leaking under houses and into foundation walls is very large; it is almost certain to occur with every house upon made land, and is always neglected by owners and tenants till it becomes insupportable; and with sickness traceable to such causes, and continual discomfort prevailing, the parties most interested still wait for the city to carry out costly general measures, thinking thus to abate their private nuisance. As a rule, a bad smell in a house means something wrong locally, and should be stopped in a day."

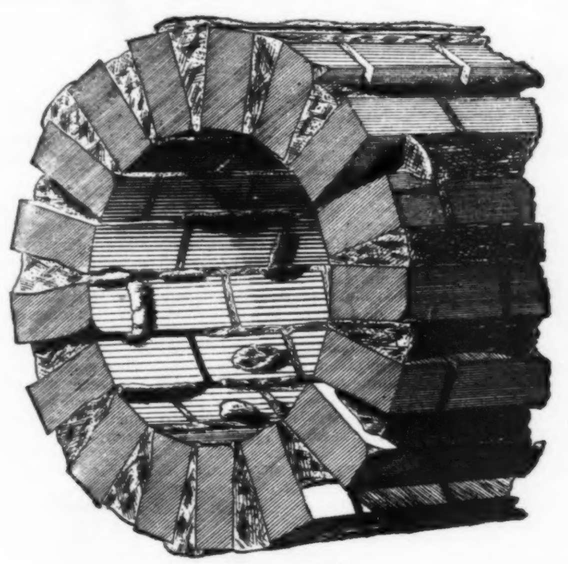


FIG. 14

The examinations of house-drains, before referred to, made by the Boston Board of Health, which aimed at the discovery of leaks by the use of strong-smelling volatile oils, show that more than one-half of Boston drains (and the proportion would probably be less elsewhere in the State) are defective from want of tightness.

A drain should be firmly and properly connected to the sewer at one of its ends, and to the soil-pipe (if this connection be within the house, as it almost invariably is) at the other. More leaks probably occur at the latter place than at any other. The inspectors of the Boston Board of Health, after pouring a little oil of peppermint into an upper water-closet, must frequently recognize the familiar odor at this point. Sometimes there is not even a pretence of making a tight-joint, the soil-pipe being merely inserted loosely into the drain. In other cases the joint, intended to be tight when made, through careless construction is not so; and again having been tight when made, it may have been injured since. Fig. 21 is from a sketch made by Mr. Bradley of a case brought to his attention, existing in the house of a Boston physician. The drain may settle away from the pipe, or the pipe may settle into the drain; an iron pipe by its expansion and contraction may break the joint between them. So liable is this place to disturbance, that when possible it is well to build it so that it may be accessible to examination at any time when there is the least suspicion of wrong. Rats frequent drains, and dig into and out of them with surprising facility. An influx of rats into a house should be taken as strong presumptive evidence of defect in the drain.

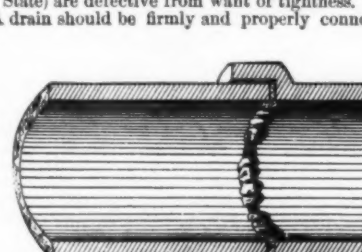


FIG. 15

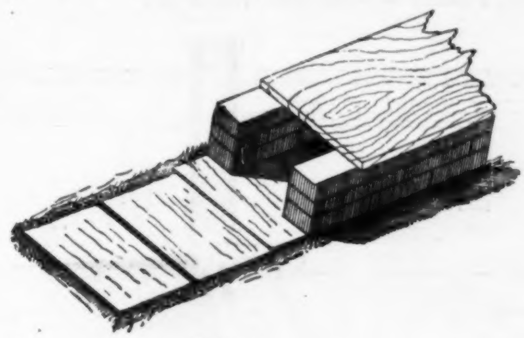


FIG. 17.

The mode of connecting a drain with the sewer affects more the efficiency of the latter than it does directly the sanitary condition of the house. But as, indirectly, the condition of the sewer as to cleanliness, efficiency, and liability to generate gases, affects, through the drain, every house connecting with it, the proper junction of the drain and sewer deserves a degree of attention which till quite recently it has seldom received.

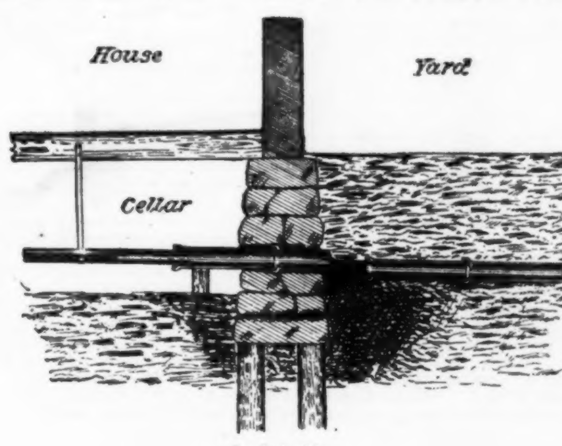


FIG 20

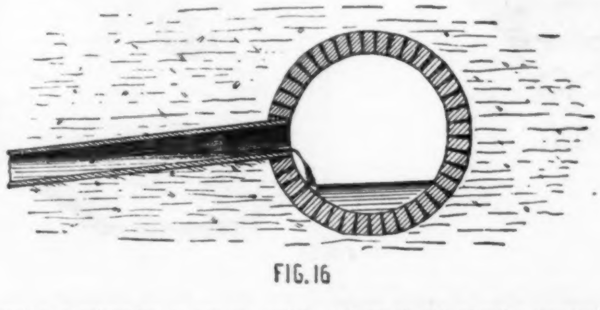


FIG. 16

A drain should enter the sewer either by a curve tangent to the direction of flow in the sewer, or at an acute angle with that direction, so that the contents of the drain shall unite readily with that of the sewer, and the velocity of neither be much retarded. Nineteen out of twenty drains in Boston, built previous to 1876, enter the sewer at right angles. The effect of such an entrance from the top or side it is attempted to show in the accompanying sketches (Figs. 22 and 23), where the tendency to arrest the flow in both structures, and to cause eddies and deposits, is shown in a somewhat exaggerated way. Fig. 24 shows the better result attained by connecting the drain at an acute angle.

It will probably be conceded, that, whatever may be the mode of connection between drain and sewer, it should be made in a firm and workmanlike manner. In practice it has generally been very loosely and roughly made. Sometimes there is no connection at all, as shown in Fig. 25, where the drain is simply brought pretty near to the sewer, and a hole broken into the latter. Of course water from both drain and sewer soaks into the ground, and occasionally the earth falls into them. Often, as in Figs. 26 and 27, a hole, somewhat too large, is cut into the side of the sewer, and the pipe pushed through, and allowed to project more or less within the sewer. Fig. 28 shows the rough way in which pipes are often connected with the arch of a sewer.

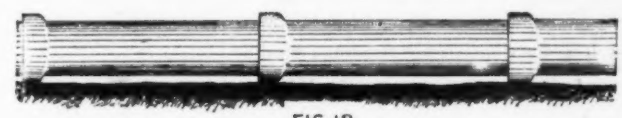


FIG. 18

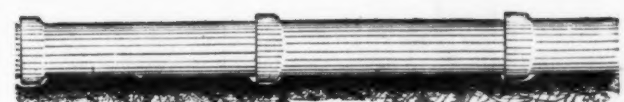


FIG. 19

The proper height in a sewer at which drains should be connected is about its ordinary flow-line. At this point the water from the drain mingles with that in the sewer with the least disturbance to both. In Boston, drains have commonly entered the sewers wherever they happened to run against them. As a general rule, they are too low (Fig. 29); and water from the sewer backs into them, making a sluggish current. Their being too low might be expected from what was shown in connection with inclination of drains; and this results largely from an effort to drain cellars into a sewer higher than the cellar floors. Occasionally a drain layer, having found a sewer much lower than he expected, has dug vertically to it, broken a hole in its top, and around the hole erected a chimney with which to connect his drain (Fig. 30). Often the hole into the sewer is much smaller than the drain which empties through it (Figs. 31 and 32). In such cases there are shoulders around the hole, on which solid matters accumulate.

The sketches that have been given exhibit what until very recently has been the method, or rather lack of method, of making connections with the sewers of Boston; and it is supposed that the manner of doing such work elsewhere in the

State has been very similar. In Boston, there has been an improvement in this respect during the last three years. The superintendent of sewers, realizing how much the efficiency of his charge was impaired by the way in which house-drains were frequently connected with the sewers, obtained, against considerable opposition, authority to require that

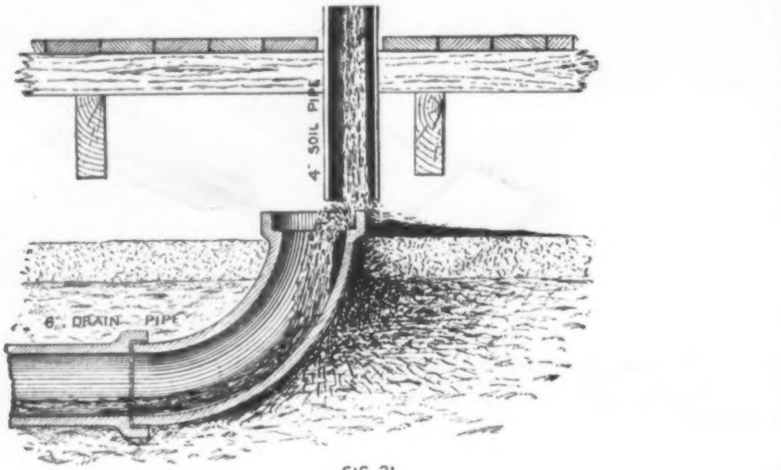


FIG. 21

any future connections should be made under his inspection. His regulations require junctions to be made with slants and curves, as shown in Fig. 33; but, of the total number of existing drains, the proportion so connected is very small. Speaking generally, it may be said that almost all the drains in old Boston are defectively connected with the sewers they enter.

The material of which a drain is composed should be durable, both on account of true economy, and, what is more important, because being generally out of sight, any decay or failure in it is not readily discoverable. For the same reason that portion of the drain within the house should never be put where it cannot be easily examined in case

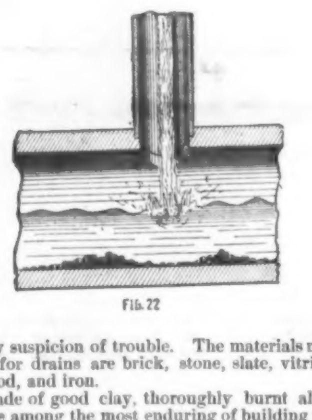


FIG. 22

there be any suspicion of trouble. The materials most generally used for drains are brick, stone, slate, vitrified clay, cement, wood, and iron.

Bricks made of good clay, thoroughly burnt all the way through, are among the most enduring of building materials. But all bricks are not so enduring. From some kinds of clay good bricks cannot be made. In every kiln of bricks there are some which are not thoroughly burnt. A soft brick will rot and disintegrate in water. Therefore, while, as regards durability, bricks may be said to be a perfectly suitable material for drains, the statement is only true provided great care is used in selecting them. Building stone and slate, often used for the tops and bottoms of drains, are generally durable (though there are instances of slate disintegrating in the course of years); but there are other reasons why their use is not to be commended.

What has been said about bricks applies to the clay drain-pipe (now so commonly used), to a degree not usually recognized. Too frequently one hears Akron pipe spoken of as though it possesses unvarying qualities. It should be remembered that such pipes are burnt in a kiln very much as bricks are. Before burning they may be air checked; like bricks, the pipes nearest the fire may be warped or fire-cracked; those higher up may be less thoroughly burnt, corresponding to "like colored bricks." Others may be quite soft, and imperfectly glazed; or the glazing may scale off by "popping."

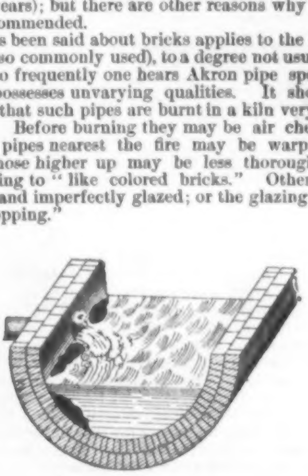


FIG. 23

Slip-glazed pottery pipes are still more liable to defects. They are made of a different kind of clay, and, being burnt at a lower temperature, are usually more porous and less hard. The glazing, which is formed by dipping them before burning into a thin mixture of argillaceous earth, forms a skin over the pipe, which at times peels off under the action of frost, acids, or hard usage. While either kind of pipe, if well made, is durable enough, poor samples of each were occasionally noticed while constructing the intercepting sewer. It is important that, in using them for house-drains, care should be exercised in their selection.

Without going into the vexed question of the comparative merits of clay and cement pipes, it is sufficient to say here of the latter, that while they can be, and often are, made so as to be very durable, yet cases where they have failed and disintegrated are frequently reported; and it is extremely difficult to judge from their appearance whether they are good or not. In resisting the action of acids and alkalies, they have been proved far inferior to well-burnt bricks or clay.

It is not easy to shape wood into the proper form for a drain. If it is always kept wet as in the bottom of a drain constantly in use, it will last an indefinite time. Where it is alternately wet and dry, as in the sides or top of a drain, it is sure to decay sooner or later. Of those seen last year,

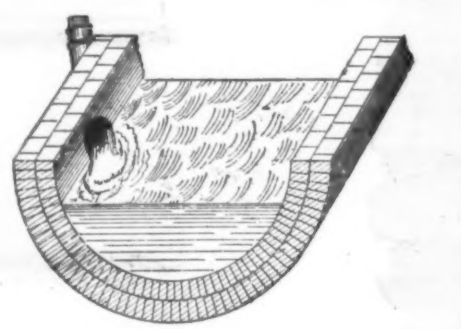


FIG. 24

the report concerning many is "rotten," "could not be held in place," "fell to pieces when handled," etc. The state of one such drain observed by the writer, in which the cover had partially rotted away and earth fallen in, is given in Fig. 34. Unless there are exceptional conditions, the use of

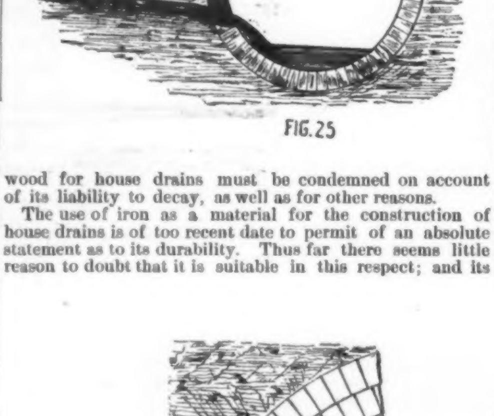


FIG. 25

wood for house drains must be condemned on account of its liability to decay, as well as for other reasons.

The use of iron as a material for the construction of house drains is of too recent date to permit of an absolute statement as to its durability. Thus far there seems little reason to doubt that it is suitable in this respect; and its many other merits will probably lead to its more extended use for this purpose.

Sanitary science, as it now exists, is of recent origin. Until within twenty years the arrangement and construction of sewers and drains were committed to mechanics and laborers, and were considered beneath the attention of educated men. Interest in the subject was first excited through the discovery by the medical profession, that a large class of diseases (thereafter call filth diseases) was induced by the presence of gases arising from defective drainage.

To investigate and cure the inefficient methods and appliances which caused these gases, lay within the province of the engineer; and hence sanitary engineering and sanitary engineers came into existence. These latter devoted themselves with ardor to unearthing evils and devising remedies for them. Like new brooms they attempted to sweep clean, and to purify at once the Augean stables they had discovered. But, like all reformers, they were sometimes carried away by their discoveries and theories; so that occasionally public opinion has reacted against an exaggerated presentment of the evils of bad drainage. People have replied, "Nonsense! things cannot be in such a desperate condition, or the human race would have died out. Our fathers lived

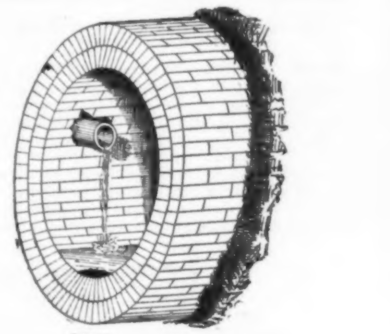


FIG. 26

comfortably to a good old age without bothering their heads about drains, ventilators, or traps; and we are willing to take our chances."

It might be answered that our fathers did not have our intricate apparatus for drainage to bother themselves about. Neither did they put on double windows, and ventilate their houses through their cellars, nor connect their drains with their sleeping rooms, as we do. The writer has no wish to be an alarmist. The risk from sewer gas is probably not so great as many suppose: it is a slight risk, but a slight risk of a terrible danger. If a man thinks there is no need of insuring his house, because his father lived in it for fifty years without a conflagration, he has a right to his opinion. What has been given in this paper, besides a few general principles, is a simple statement of what exists as seen by the writer and others. The question of plumbing has not been noticed, because the writer is not especially qualified to discuss it. He merely speaks whereof he knows; and the evidence is

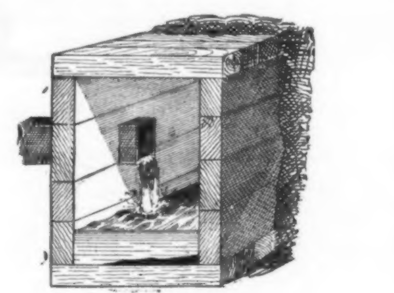


FIG. 27

submitted without argument, for the consideration of those interested.

Should any one, admitting the evil, ask concerning a remedy, the answer is twofold. For the defective drainage which already exists, there can probably be no immediate radical relief: it can only come as people learn to appreciate the danger of sickness and the value of health. When householders become sufficiently interested to wish to know where and what their drains are, and to make a few investigations with bottles of peppermint and otherwise, then will the better day be at hand.

As to what may be done to prevent an increase of bad work, a suggestion is offered. It is safe to assume that every man who builds a house for himself desires that its drainage shall be fairly efficient: unfortunately it is not equally safe to assume that he will spend the time, thought, and money necessary to make it so. Now, since a defective house-drain

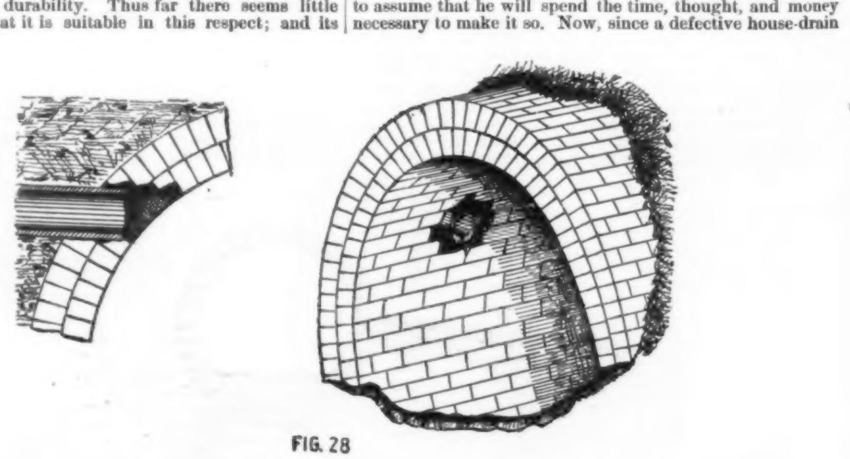


FIG. 28

may affect not only the owner of the house, and his family, and all who may thereafter reside there, but also the whole neighborhood, would it infringe on personal liberty too much to require that the house drain, if no more, shall be built according to approved plans and under municipal inspection? Merely to require that before beginning such a work a plan of it should be put on record, would accomplish some-

thing. In drainage, to have some plan, even if a bad one, is better than none. It insures a little thought beforehand, a knowledge of the height of the sewer, and an adaptation of the drainage to it.

In Frankfort-on-the-Main, which has lately been sewered on the most perfect system and with the latest results of engineering skill, it was found impossible to realize the expected benefits unless some control was exercised over house drainage. In that city, connection with the city sewers

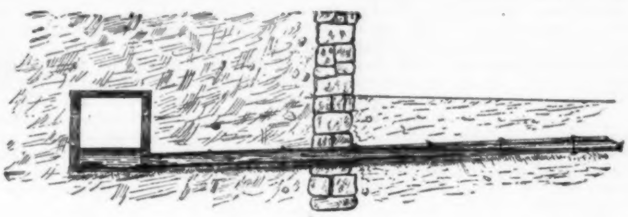


FIG. 29

is not compulsory; but if any one desires, as nearly all do, to drain into them, it is required that detailed plans in duplicate, showing everything to be done, shall be filed, one with the board of works for its approval, and the other to be kept at the house. The whole work is done subject to its constant inspection of materials and workmanship.

In the Eighth Annual Report of the State Board of Health, January, 1877, pp. 130-132, are given the conditions under which buildings, etc., are allowed to be drained into

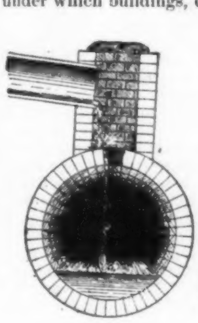


FIG. 30

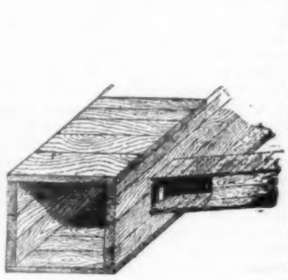


FIG. 31

the new sewerage system of Frankfort. The plans to be filed are referred to thus:

"Whenever the drainage of any house, yard, etc., is projected, the owner of the property in question must, after having signed the requisite certificate, furnish to the department duplicate plans bearing the signature of the contractor, and containing a map of the locality on a scale of at least 1:2,500, a ground plan at least 1:250, and a sketch of the main drain and branches with its horizontal plane on the same scale as the ground-plan, and its profile at least 1:125.

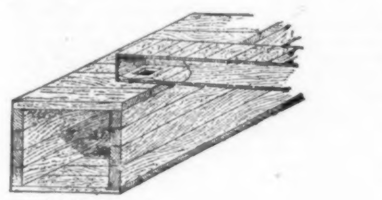


FIG. 32

"The certificate and one of the duplicate plans are to be kept among the documents of the sewer department: the other plan must be always ready for inspection by the officers at the place for which it is designed.

"All plans presented must contain all the works projected; the exact position of sinks, gullies, traps, and other details; the direction of the superficial water carriers; the positions of the rain-spouts, cisterns, privies, waterclosets, cesspools, vaults, wells, pumps, and other arrangements for water supply; also the levels of the surface where the works are projected, including the grades of the latter, the depth of

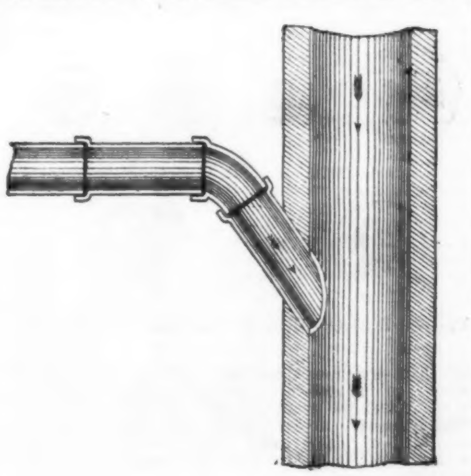


FIG. 33

the cellar, the lowest levels of the ground, and, where possible, the depth of the foundations—all to be given by the standard grade."

This preparation of plans is the pivotal point about which centers the whole regulation of private drainage. Its effect is probably, that, as the owner and mechanic are unable to make the plans with the requisite nicety and accuracy, they are prepared by an engineer familiar with the proper designing of such structures. It will be noticed that this filing of plans is not to be a mere form, but that a duplicate is to be kept on the ground to be constantly referred to in constructing the work.

The question of sewerage is forcing itself upon the attention of all our cities and towns. Boston has appropriated between three and four millions of dollars for a system of interception, whereby its sewers shall discharge freely at all times, and their contents be diverted from the vicinity of dwellings. It is the first, most important step, and, as the taxpayers realize, costs dearly. If the full benefit of this improvement is ever to be realized, it will only be when the house drains and common sewers are rendered equally efficient, and the fundamental condition of perfect sewerage—an uninterrupted removal of waste matter from the house to its final place of deposit—is attained.

PLANT AND ANIMAL LIFE.—I.*

By A. R. GROTE, A.M.

THE same methods that we pursue in a study of geology and the surface phenomena of the earth we may apply in botany and zoology, because in these higher fields of inquiry we have merely to do with a more complex mixture of similar materials. Plants and animals are made out of the atmosphere and certain elements of the soil and waters. Now, the atmosphere belongs to the earth's surface, and stands in certain definite and interchangeable relations with it; so that the view that plants and animals are simply more or less detached parts of the globe itself, may seem odd, but will be found more reasonable the longer we study and think over it. The round of their existence is not unlike that of a body of water, for instance, which is fed by the atmosphere and returns by evaporation, while it deposits its denser constituents on the floor of earth which it covers.

And just as in order to comprehend the past changes in the earth we must investigate its present appearance, so must we study existing plants and animals to know fossils. By examining springs, swamps, lakes, rivers, and seas, and again by looking at volcanoes, reefs, mountains, peninsulas, islands, and continents, as they now appear, we obtain a comparative knowledge of such phenomena. And when we go below the surface, we find indications of the former existence of such assemblages of matter. How these came about is a deduction to be made after we know how our present surface phenomena are produced. Geology is, then, the study of the physical geography of past epochs. And in the same way, by studying the anatomy and development of existing plants and animals, we can carry the results to the fossil floræ, and faunæ, whose remains we find buried in different geologic masses and material.

Life and structure are seen to go hand in hand, so that in discussing the "life of plants and animals," we must study their structure. Now the ultimate test of the existence of what we call "life" is motion of some kind, however feeble or hidden. Although we have motion where we deny life, we yet invariably associate life with motion. Let us first devote a little time, then, to matter and its motions.

The movement of the matter forming the surface of the earth, and which is unceasing, is the movement of its ultimate particles. The result of this movement of its particles is seen to affect the general size and shape of a mass of matter, whether we survey a cloud, a river, or a mountain. This movement of the particles against each other is easily seen by the movement of the whole body in the case of the river and the cloud, but not so readily apprehended in the granite. Where the motion is not seen, we call the body rigid; where under our eyes it changes shape or size, we call it elastic. But this is only a relative classification to suit our senses. Perpetual motion is everywhere, perpetual rest nowhere. We find, ultimately, that the particles of matter move according to their weight. They move against each other, as it were, seeking rest, seeking something upon which they can depend. They impart their motion to the next particle against which they fall, and if they cannot move this, it is because the next particle beyond the one which they strike is for the time sustained by its own motion or that of other matter acting upon it. This is the simplest conceivable form of motion. But motions are very complex as we find them in nature. And this is so because the relations of each atom are various. Complex as movements are seen to be they all are found to depend ultimately upon the kind of matter of which the thing which moves is made up and the relations of its particles to each other in combination.

Force is being continuously exerted, and we only can conceive of force as being exhibited by matter, just as we can only conceive of mind as combined with its physical agent, the brain. The discovery of the ultimate identity of all of what we now recognize under the name of elementary substances would give us the primitive form of atomic matter. Lockyer claims to have proven such an identity to exist already. But although we are doing our utmost to find out the appearance of the ultimate particles of matter, our senses are too coarse to perceive them even with all the aids yet discovered. Now, until we can take cognizance of them by some experimental means, we cannot know that they exist. But we know that the particles of what we call elementary matters differ in some way, since these latter have different densities. Hydrogen weighing 1, the same volume of oxygen under the same condition weighs 16, and so on.

We must look upon all existing aggregations of matter whether we survey rocks, waters, atmospheres, or plants, and animals as merely existing for the time being in their present shapes, because the attraction among their ultimate constituents is stronger than the attraction of the latter for extraneous particles of matter. Thus a stick is not at once disintegrated in the water which bears it along, nor is, in fact, any, change probably absolutely instantaneous.

Plants and animals are found to be elastic bodies, because they change (under our powers of sight) in shape and size. They are compounds of the same matter as we find on the surface of the earth, because we can convert them into these separate kinds of matter, and weighing each kind by itself, we can find their totals to agree with the weight of the original. In these lectures on plants and animals, I include

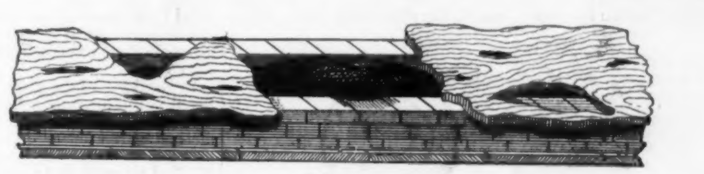


FIG. 34

man as a kind of animal, because he is found to yield to the same process.

Man is seen to agree with many animals in details of shape and function; and beyond this agreement in general structure, the ultimate particles of his body are such as we find in rocks, seas, air, and trees. Every element found in plants and animals is found also in an inorganic condition. In saying this, I do not by any means lose sight of the real differences between ourselves and other animals, or between two persons of different mental capacity, who, perhaps, might yield similar chemical results. But such differences are in themselves the result of a series of ultimate molecular changes which are destroyed in the crucible. Such an analysis gives us only forms of amorphous organic matter. It merely carries us back to the original organic composition, and gives us, in addition, certain of the elements which the body has gathered along the road of life.

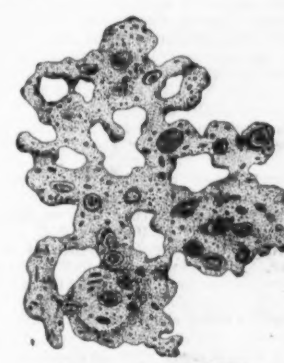


FIG. 1.—BATHYBIUS.

Exactly as we find in continuous succession, the sand and then the sandstone, the mud, and then the shale, the lime and then the chalk and marble, so do we see the matter that makes up plants and animals in various stages of its development, and moved always by the single force that rules the universe. What we call an explanation or understanding of anything consists merely in our appreciation of its consecutive stages. If we had not loose sand the solid sandstone would be less intelligible to us, or if we did not see how a moraine is formed to-day in Greenland or the Alps, we could not understand the ancient unstratified heaps of material which testify that a glacier once passed down the valley of the Connecticut. And so it is with plants and animals. The way in which the species we see to-day grew to be what they are would be unintelligible to us if we could not see the way in which the existing individuals themselves are developed.

Fortunately we not only see the inequality of development, by comparing the different kinds of animals and plants together, and thus studying in reality different stages in general evolution, but it is found that the different stages of individual growth recall the past history of the species and show us what it has passed through to be what we find it is to-day. And in these lectures we are not discussing the reason for the existence of plants and animals, but how they may have originated, and have been and are produced.

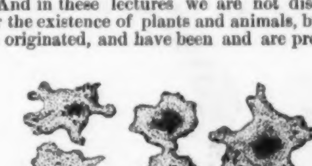


FIG. 2.—PROTAMŒBA.

We have two ways to check our conclusions as to the true succession of plant and animal life. The first way is by collections of such remains of former existing plants and animals as we can find in the crust of the earth. Either their harder parts, or else the impressions they have made in the substance upon which they have grown, walked, or lain dead, reveal alike their existence and structure.

And the second way is by a knowledge of the different forms which existing plants and animals pass through from their inception to their decay. These two independent lines of research must check each other, and we can rely upon them to give us the actual facts of succession in the organic world. That is, the study of paleontology, or fossils, and the study of biology, or the development of existing organisms, must give us at last the approximate truth with regard to the origin and sequence of life upon the earth.

But there are difficulties in the way of obtaining this information. The first lies in the incomplete record in the rocks. It is quite clear, from what we have found by digging and excavating, that the remains have not all been preserved. The soft plants and animals, and the soft parts of

* A lecture delivered in the Popular Scientific Course, before the Buffalo Society of Natural Sciences, Feb. 1, 1879.

animals have decayed or left few traces. There is, again, an affinity between disintegration of rock or loam masses and the decomposition of organic bodies. The rock basins of our great lakes have been emptied by ice and water. In Asia the rock basins have been largely emptied by the action of sand and the currents of wind sweeping over the steppes. But in both cases the dispersion of the rock elements was assisted by the decomposition of the mass, rendering it friable and dispersive. So there is a loosening movement in decaying organic matter which renders its dispersal in various ways, by natural agents, a matter of regular accomplishment. And by the atmosphere, rains, or shifting of portions of the earth's crust, quantities of fossils have been destroyed. Here in Buffalo, for instance, the rock beneath the drift and soil is Silurian limestone, one of the oldest deposits. Other

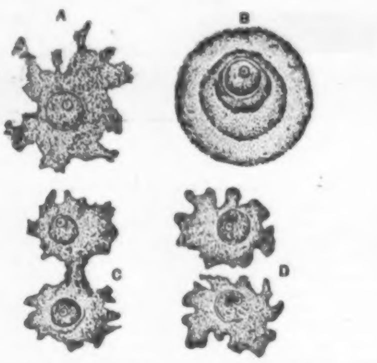


FIG. 3.—MULTIPLICATION OF FRESH WATER AMŒBA.

deposits bearing fossils must have overlaid this one, and have been removed, probably by combined action of ice and water, and scattered in broken particles over a wide portion of the surface of this continent, just as we find bowlders lying in our fields which the same ice brought us from the Canadian highlands. Again, this deposit of lime-rock itself is now being used in manufactures, and the fossils we find in it of crab-like animals and algæ, are being destroyed and removed from our knowledge by the quick action of the limekiln. Finally, but a small portion of the earth's deposits has been scientifically explored.

To understand structure we must pick animals and plants to pieces, and besides, study their growth and movement when entire.

Our difficulty in the study of biology lies in our want of practice in rearing many kinds of animals and our want of facilities for doing so. Further than this, we have to overcome, by continuous study and observation, our natural inability for getting a clear mental picture of the various stages we observe. In looking at an object we do not notice at first all its peculiarities, and in proportion as we know allied objects is our comprehension of the new object increased. We know a thing when we see it again, and we know parts of a thing when we see them again in a different combination. In fact, if there were no similar objects with which to compare anything, our comprehension would be hampered to a degree which we can hardly realize. This is the reason why the study of one organism by itself is so unsatisfactory. We must compare the parts of one animal with the parts of another, and in this way come to appreciate the differences and resemblances between the two objects. This science of a comparison of parts is called morphology. In this we study by comparison the different parts of animals and plants. We have to note, also, the succession of appearance of the several parts in the general development.

So far, then, as we have gone, we have found that plants and animals are composed of the same materials which we find distributed in the earth's crust; and we have found reason to believe that all the different forms of matter depend upon the configuration of their ultimate particles.

But there is this distinction at the outset, that there is a certain complexity in the material which goes to make up the organic world, while the different substances themselves which form this life material are found in other combinations, or in a simpler form outside of it. We can make this clear by illustration. Carbonic acid, *i.e.*, two particles of oxygen and one of carbon, is an inorganic compound. We will now take the elementary groups of particles, which is known to the chemist as formyl. This radical differs from carbonic acid in the substitution of one atom of hydrogen for one of oxygen. It is found as a radical in

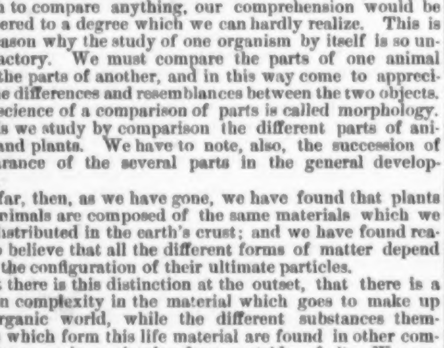


FIG. 4.—GROWTH OF THE "RED SNOW."

the juice which certain ants give out, and it causes their stings to irritate us. It is the basis of formic acid, and is found in insects generally. It is found also in the glands of the common nettle, in combination with further atoms of hydrogen and oxygen, and produces here again a similar effect. Now protoplasm, which Prof. Huxley calls the physical basis of life, because it enters into the composition of all plants and animals, is a much more complex combination of the same elements with the addition of nitrogen. Wherever we find life we find protoplasm. But the reverse is not always true. We may have protoplasm which is dead and undergoing a different kind of motion in uniting with elements of the air in decomposition. In one case the live protoplasm is receiving fresh material from the outside to make good the loss of its constant waste; in the other it fails to make good that loss and also to secure its own perpetuity as an organic compound.

Let us look at this problem from a different standpoint. The green coloring matter of the leaves which is contained in certain surface cells, takes in the carbonic acid of the atmosphere and decomposes it, or, in other words, effects a separation of its atoms under the action of the solar rays. The energy or life requisite for this chemical action is provided by the sunlight. It does not take place in the dark. The coloring matter directs the energy, but does not furnish it. In a similar way may not protoplasm, the contents of organic cells, direct energy received from without, or may it not start with an original amount of energy derived from its chemical composition, which force is gradually dissipated, until we say the living matter is dead? Does it not, in fact, exhibit both phenomena in being, as we say, alive?

In speaking of the growth of plants and animals as compared with inorganic substances, we know this growth by a change in form and size. At first sight the difference in the method of the formation of mineral masses and the living protoplasm seems very great. Let us look into this a little. We find minerals in two different forms, first in the shape of crystals and then in that of an amorphous mass which depends on the quantity of the mineral itself for its form.

Sulphate of copper is found in crystals, but we may reduce these crystals to a shapeless mass by merely drying them. Such crystals grow by juxtaposition; that is, similar atoms are added to them on the outside. Now, organic bodies grow by what is called interstitial growth; that is, new cells are formed between other cells. The chemical composition of the new matter or food is at the same time changed by the process of digestion, and in this way the food is assimilated.

But if we take a drop of water and surround it by a damp atmosphere, it absorbs the water held in the air, and the new particles of water permeate the drop interstitially between its atoms. Again, if we add salt to the drop of water, the chemical composition of the resulting liquid is a new one; there is an interstitial addition throughout the whole drop. But if we put the drop of water in an atmosphere of ammonia gas, the gas combines with the water, forming a totally different substance—hydrate of ammonia.

The process of assimilation in the inorganic world is thus proven to be paralleled with that of growth in plants and animals. In both cases what actually has taken place is only known by the results. In both we have the addition and assimilation of fresh matter. The point where animals and plants begin, and where the crust of the earth, or rather the surface of the globe, leaves off, is then not an easy one to define. In old times whatever moved was thought to be "alive." The ancient Greeks sat in judgment upon stones which had fallen and killed persons, ascribing motives to such motions; and science can only say to-day that the real difference between plants and animals and inorganic objects is one of chemical combination.

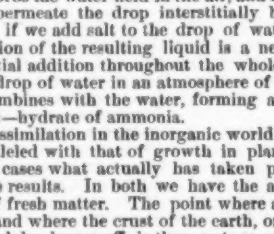


FIG. 5.—BRYOPSIS: SPORES AND COMMON APERTURE ENLARGED.

But this is the discovery of science that matter has really more properties than it has been commonly believed to possess, and also, that in one way or the other, it produces all the complex phenomena of life on this earth.

Before speaking of the differences between plants and animals as two divisions of animated nature, we may briefly notice the fact that we have never yet been able to produce the living matter life in our laboratories. The chemical constituents of protoplasm are given, but, as in the case of the diamond, which is said to be pure carbon crystallized, we have not been able to make the substance from our knowledge of its elements. The complex mixture of carbon, hydrogen, nitrogen, and oxygen, as we find it combined in protoplasm, and as such displaying the phenomena of life, is yet beyond our manufacture. But we can and do make other substances out of these and other elements in our workshops every day, and our experiments with similar matters have brought us many discoveries and improvements.

Whether we shall or shall not attain to the manufacture of this matter of life, there is evidently less evil to be apprehended from its discovery than should have been feared from the discovery of gunpowder, which has brought so much additional sorrow into the world, great civilizer though it may be held to be.

As to the manner in which the elements of protoplasm first combined we know not, but this we know, that there is nothing in it but a peculiar arrangement of certain known substances. Why such an arrangement did not originally arise as other compound substances are shown to have arisen, is a question difficult to answer. It has been stated that the earth, being held to have passed through a stage of intense heat, all life germs must have been then destroyed.

One fault of this proposition lies in the word "germ." By this word a specialized cell or a seed, complex and high organisms, are intended. But we have now living matter which is not produced by "germs," but by division of pre-existing matter. And again, the process of cooling, and the chemical action which provides plants and animals with food, occurs (as we see) subsequent to the heated stage of the earth. Animals and plants depend so closely upon their nutriment that they cannot exist in default of it. They exist because of it, rather, and being surrounded by assimilative matter, the pre-existing state of both that matter and themselves need not enter into the calculation. Certainly if the intense heat could again be set up, all life would be destroyed, but in the process of cooling the elements would reunite in certain definite ways, and one of these certain definite ways might bring together carbon, hydrogen, nitrogen, and oxygen with the result protoplasm, or the matter of life. And action set up in this way might have like subsequent effects with those which we are trying to explain in this manner to-day.

But, indeed, on the common ground where the chemist and the naturalist at last meet, they can find no necessity for the introduction of anything foreign to the soil of the earth for the appearance of life upon its breast. They have hunted down the matter of life to its smallest compass, but from its feeblest pulsings to the beatings of their own hearts they find a gradation which gives reasonable hope for a future and more glorious development for life upon our planet.

Plants and animals are found all over the surface of the earth, in its waters, and, since the dredging expedition of the Challenger, we can say over much of the ocean bed.

Until quite recently all animated nature was supposed to be divisible readily into two divisions, which naturalists, with a gross flattery of existing political institutions, called the vegetable and animal kingdoms.

But already during the first half of the present century our acquaintance with certain lower forms of life had so grown that it became clear that we had to deal with organisms which were neither plants nor animals. An American scientist, the late Dr. Wilson, of Philadelphia, proposed in 1863 to call this new class of organisms *primalia*, and Haeckel afterwards discussed the group with much greater felicity under the name *protista*.

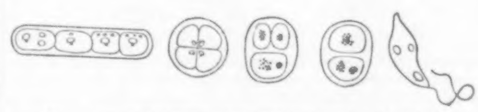


FIG.—6. GROWTH OF EUGLÆNA AGILIS.

Before entering into an illustration of this common ground from which we believe plants and animals have alike developed, and which lies between them and the mineral constituents of the earth's crust, let us discuss the differences between plants and animals themselves. It was held by Cuvier that a fundamental difference existed between plants and all animals, in that the latter possessed a stomach, while plants had no such digestive cavity.

What is a stomach? We know something about our own when it aches or when we have filled it to repletion; and our poor unkindly feel its presence in the winter time when it is empty. It is a sac, lined with a membrane from the glands of which an acid fluid, the gastric juice, is secreted, which latter acts upon the food taken into the stomach by dissolving, separating, and reassorting its parts. Without its intermediacy our food could not be assimilated. Now in the pitcher-plants the juices of insects and other nitrogenous substances are taken into the circulation through the surface pores, which act as surface stomachs. They are found to contain a digestive fluid, and they, therefore, replace in function the stomach of animals. Again let us turn to animals. The stomach is wanting in some of the lower forms, and, according to Huxley, in several species of internal parasites. Hence the difference between plants and animals, based on the presence or absence of an alimentary cavity, though important is not absolute, and sometimes falls away. The main difference between animals and plants has been held to be that animals, as a rule, derive their food from plants or animals, whereas, plants, as a rule, take their food from the soil direct. So far as their structure goes, we find that the cells of the plants are inclosed by hard, unyielding walls, and are thus more inaccessible than the animal cells, which are inclosed in a yielding membrane. We shall come later on to a discussion of this point and the circumstances which may have made it important at one time in the differentiation of cell development. When we come to the matter of locomotion we find that numberless plants like the yeast plant move about. Some are fixed during a portion of their lives, and free during another certain portion.

Such a living body is the *æthalium* described by Huxley, which appears first as a fungus upon decaying vegetable matter. Afterwards it loosens its fastenings and becomes an actively moving body, which takes in food by inclosing it, and thus seems to be an animal. But if life depends on movement we have the circulation in plants, and, above all, the peculiar movements of life-matter in vegetable cells, which have been described by many observers. The animal and vegetable cells are seen to be wonderfully alike. It is by overcoming our first impressions by renewed and repeated observations, as I have already stated, that we at last come to the understanding that plants are not to be entirely removed from our sympathies. For their distant consanguinity their structure forcibly appeals. As to the living matter of plants, it is just as complicated, so far as its particles are concerned, as that of animals. Nitrogen is proved to exist in plants as well as animals. Starch, cellulose, and sugar are produced by both plants and animals. Again, the green coloring matter of plants is found in certain low animals. With regard to the respiration of plants and animals, no essential difference can be made out. In the sunlight the

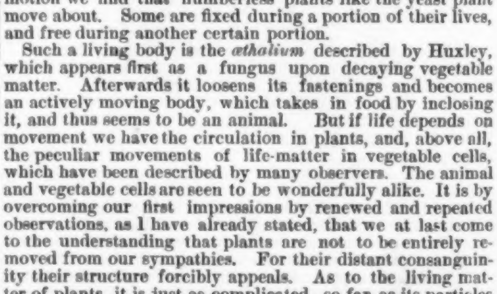


FIG. 7.—EGG OF DOG IN DIFFERENT STAGES.

green plant decomposes carbonic acid and exhales oxygen, while the animal absorbs oxygen and exhales carbonic acid. But in the dark the plant behaves like an animal, and absorbs oxygen and exhales carbonic acid. And, again, in the lower kind of plants called fungi, which have no green coloring matter in their surface cells, respiration is always animal like.

Both plants and animals absorb and transpire water, and plants not only absorb through their roots but through their leaves, so that sprinkling is always of great benefit to plants whether they are growing or we have cut them into bouquets. A difference at first sight seems to consist in the fact that animals go to their drink, but the drink is brought to the plant. But this is seen to be a relative distinction. The seeds of certain plants are planned so that they may be carried by the wind. Now, without moisture these seeds

could not grow. There is a danger of these seeds settling on dry places, and undoubtedly many do so settle and never grow. But there is also a danger that they may be blown away from damp places where they could grow. Now, it has been found that certain of such seeds pour out a sticky substance on contact with wet, and this sticky substance holds them until they can penetrate the ground and germinate.

Again, as to individual movement, the twining of a convolvulus around its support, and the contraction and expansion of the leaves of the sensitive plant on being touched, are comparable to muscular movements in the animal world. Plants as well as animals have been found subject to the action of anæsthetics. Everywhere the seemingly absolute barriers of distinction between plants and animals are seen to break down under investigation.

We will now turn to the simplest form of animal matter or protoplasm, as we now find it. By far the largest proportion of animals and plants are found to consist of a great many individual cells, and originate from an egg or seed. This latter fact is stated as a rule by the older naturalists—everything comes from an egg. Now an egg or a seed is a single specialized cell, which is seen to develop by a simple division of the matter which it contains when the seed bursts and discloses the plant, or the egg hatches and the chicken creeps out. This process of division of the original matter of the seed and egg has been carried through a large number of intricate stages, the result of which is the animal or the plant, which for further growth depends upon the substances which it finds around it. You will remember that in the first part of my lecture I drew your attention to the fact that our comprehension of the manner in which the present crust of the earth was made up, was assisted by our knowledge of its different stages. We could see that the stones were originally broken off the primitive rock in large lumps by the action of wind and water. We could see that these stones were filed down to sand by being rubbed together in streams and then the finer particles deposited in layers on the river bottoms. These hardened to sandstone in time, and we find that we can mine the ancient river bed, and hew out its once shifting sands to build houses with, and all these processes we find going on to-day, so that the various steps which lead to the formation of sandstone can be watched and appreciated. From a knowledge of the particles of the primitive rock, and the finding of these same particles in the latter sandstone, we could logically conclude that they were the same thing at bottom in different forms, and undergoing different processes. Science not only deals with facts, but with their succession, and is logically bound to come to some conclusion as to the meaning of their connection. The condition these rocks were in was determined by their environment, the one force which moved them all being continuously exerted upon them and causing their change of form. Exactly so must we study the changes of the egg of an animal or the seed of a plant.

We know the chemical particles which make an egg or seed, and comparing them with the particles which go to make up the plant and animal we find them similar. Further than this, since the whole body of the animal or plant is built up by a succession of such cells, we can conclude that the eggs and seeds containing the nucleus of a fresh individual are really specialized and free cells, and that the new organism starts as one of the units which made up the body of the parent. In the egg every division of the contained matter must be studied, for it is found that the stages of the embryo recall some existing or fossil perfect form which did not pass beyond that phase of the common matter of life. But the egg is a cell and the seed a cell, and we find the higher animals and plants to consist of aggregates of cells. Now, any cell is, to a certain extent, a complicated structure. It has a body wall and a separation between this body wall and the contained mass. Obviously this form of animal matter is not the simplest conceivable. It is already crystallized matter, matter which has taken on a definite shape. Just as we found that minerals were either crystallized or in an amorphous mass, dependent upon its aggregate for its shape, so do we find life matter in a still more simple form than the cell. We find it in the *protista*, mere aggregations of the matter of life without any special parts whatever, but which still absorb some adjacent matter as food, and multiply. And we must conclude that in this group are organisms which are lower than animals and plants, because they show no division of their mass into cells; and further than this, we find the cell first forming in the higher organisms of this group.

The difficulty for believing in the spontaneous generation of any celled organisms is obviated in considering these lowest forms, which are mere loose aggregations of protoplasm without the apparent motion which characterizes the higher protista. Activity, or more violent chemical action among the particles, heralds the formation of the cells.

The best known example of this kind of protista is *bathybius*. This, as observed by Huxley and Bessels, is simply a mass of protoplasm, containing entangled with it certain substances, which are probably secreted by it, as they are found to be formed of the lime which is contained in the mud upon which bathybius rests on the bottom of the ocean.

This mass of protoplasm manifests motion and takes up foreign matter in its substance, as can be proven by tinting with carmine the water in which it is kept. This species has attracted some attention from the fact that it has been denied an animal nature. We have seen, however, that the basis of animal life is essentially mineral, and we shall see that the same appearance is shown by other protista which move in a more definite manner, otherwise not differing from bathybius. It matters little or nothing, considering that the boundary line between the organic world and the inorganic is difficult to draw, whether bathybius is held to be alive or not. It is, however, noteworthy that those who are the best judges of the matter considered it to be really an organic body. In another form, called *protamœba* found in fresh water, we have, according to Haeckel, an amorphous body of protoplasm just like bathybius, being in fact as structureless, which changes its form by stretching out portions of its substance into shapeless finger-like bodies, called false feet or pseudopodia. It is as if it were feeling its way along against its environment. When any decaying substance comes in contact with this protamœba or any live microscopic organisms, it assimilates them by drawing them into itself and then absorbing the particles of matter they are composed of, which go thenceforth to make up its own body. It does so by an evident movement and aggregation of its particle around and about the substance. This assimilative action must be regarded as chemical and mechanical. It can be seen under the microscope and its details inspected. It is quite evident that the contact with its food is accidental, that is, in its movement against its environment it comes into contact with a substance which stands in chemical affinity to itself. It collects its food as one drop of water collects another. Its appetite is the appetite of each of its particles for a particle in the body it absorbs.

The protamœba increases by simple division. After attaining a certain size, it divides into two portions, and the approach of this division is seen by a simple constriction of the body at the middle. Both of these and other allied forms show no cellular growth. They are then to be regarded as simple masses of independent protoplasm, and as such inferior to both plants and animals.

Higher than these early forms are masses of protoplasm, which show the formation of a cell, and are generically called *amœbæ*.

One of the lowest of these forms has the cell surrounded by protoplasm, which is free as in protamœba. This organism assumes what is called a resting stage. The false feet are drawn in, and the little globule becomes spherical.

But this dividing of the mass of protoplasm is interesting, because it is here evidently a division arising from an excessive increase of bulk. It cannot keep together, and it splits because the external pressure is greater than the attraction of its particles for each other. It divides for the same reason that a drop of oil separates on a table when we have added more oil than can be held in a single globule. You may have all noticed this latter phenomena. It is no more and no less "mechanical" than the splitting of protamœba. By a division all cells multiply. There being too much stuff for one cell, two are formed. Hence we can see that no matter how complex propagation may be among higher plants and animals, it is nothing but a growth of the organism beyond its limits of size. Originally every cell is a single globule of protoplasm, but its form is dependent on a segregation of its atoms. A more dense portion has separated itself and becomes the nucleus or kernel. Afterwards many cells exude a true skin or membrane which envelops them.

It now consists, according to Packard, of a spherical lump of protoplasm, in which is a nucleus with an included nucleole, and the whole surrounded by a cyst, or cell membrane. After a while this membrane is ruptured, the animal becomes again free. The cell itself begins then to divide, and finally two cells are formed. A division then ensues in the surrounding protoplasm, and the two cells are separated, forming two individuals. At this point we come to a life history where we may conceive a difference to have arisen which has separated plants and animals. You will remember what I said about the difficulties in the way of tracing out the history of the past living forms in the rocks. The soft parts, we found, would leave no traces. Now, all the paleontological history of the amœbas, or free protoplasmic cells, is lost. We have to come to some conclusion from the transformation of existing kinds. In this low kind of amœba we have the first step to forming a hard casing to the cell when the organism enters into a state of rest. Were a thickening of this cell wall to take place the cell could no longer surround its food and assimilate it. Its food would come to be taken in by absorption in a fluid state. In other words a difference would arise in regard to its nutrition. Cell multiplication would take place as before by division, but the plastic condition would become less and less necessary to the growth of the organism, which thenceforward would take its place among the plants which derive their sustenance from the simpler forms of mineral matter. On the other hand the naked cell stage with its pliable envelope, stretching out false feet, itself a stomach surrounding its food, may be regarded as the original stage of the animal organism, which in its parts conforms even now to the most essential conditions of the amœba cell.

Let us take a step further on each side of this starting place of plants and animals, and study their growth.

The plant called "*red snow*" is a mere microscopic globule, so small that by itself it escapes the eye, but in a mass it gives the snow, in some localities, its peculiar color. It is one of the lowest algæ. As it is found, according to Clark, it consists of a small globular cell with thick cell walls, and filled with a granular substance. In subjecting this cell to the action of water it grows in size, and a separation of its mass into two and then four divisions is gradually accomplished. Each of these divisions contains a nucleole, and presently two long filaments grow out from its transparent end opposite the nucleole. The spores then separate from each other, and their filaments are seen to lash about in the empty space. Presently the cell bursts, and away go the tiny spores, moving hither and thither. In process of time, however, a film appears on the surface of the ever active spore. This gradually thickens. The spore settles down, the filaments disappear, and we have again before us the globular cell with its granular contents with which we commenced.

Now, we have here a plant which is comparable to the resting stage of the amœba. It is a cell with thick walls, imbibing its nutrition through them, and multiplying by internal division, each division leading a separate existence and repeating the same cycle. We have, in fact, in nature before us a stage in the evolution of plant life, and were all the amœbas preserved that have ever lived on the globe we would no doubt have various intermediary stages before us between the resting stage of amœba and the globule of the "red snow."

And while we are about it let us take a further step in the development of plant cells.

Here we have *bryopsis*, a sea weed, one of the algæ a little higher than the "red snow." It presents the appearance of a leaf, but it is only a single cell grown out into the form of a leaf, its shape determined by the same dynamical force that makes a mountain, viz., the equalization between the action of its component particles and its environing particles. Inside its development is similar to that of the "red snow." It becomes filled with little lively spores, which, however, emerge from a common aperture, and do not destroy the form of the parent at their birth. They move about for a while and then settle down to grow for themselves, just as the red snow does. Higher than this are algæ which consist of an agglomeration of distinct cells.

In all of these spores are developed just as they are in the unicellular bryopsis. The entire plant becomes a string of producing cells. Above these are algæ which contain specialized cells performing the office of reproduction alone.

The asexual reproduction of the algæ, by means of zoospores—cells which move about like living animals—has been known for a long time, but only lately has the copulation of these zoospores been discovered, showing an intermediate link between sexual and asexual reproduction. In *ulothrix zonata* and in *botrydium lunulatum*, two or more zoospores merge into a single cell at a certain stage of development of the plant.

A very interesting step toward sexual reproduction of the algæ, which is, that one egg cell, which is at first perfectly at rest, is impregnated by a moving egg cell, has been discovered by Reinke at the zoological station at Naples, in *zanardina cellaris*. Here we find two kinds of zoospores, one large and one small; the large ones after very little movement settle down to rest, and at that time the small ones connect and are gradually taken up by the larger ones. Sexual reproduction is almost reached in this case, only the female egg cell is active for a short time before impregnation. We have then here the stages between simple multiplication by cell fission and sexual reproduction, where the male and female cell characters are separated and have to be united to produce further development by division of the embryo.

We have here every link from this one point of view in the make up of plants, and the history of all plants is but an amplification and more complex arrangement of cells in a series which commences with the single cell of the "red snow," the copy of the resting stage of amœba.

We have in this succession of hard coated vegetable cells one phase of evolution, inasmuch as we see that from a simple type a more complex organism is gradually built up. We will now follow the development of some soft protista cells, from the multiplication of cells similar to which animals may have arisen.

In *euglæna* we have a mass of protoplasm within a naked cell. This organism lives in brackish water. When the cell is about to divide it increases in bulk and the filament is lost. The cell divides within itself into two, three, four cells, each the equivalent of the other, containing a nucleus, and destined to lead a separate existence. Here we have a free naked cell, which completes its life cycle by multiplying itself, returning to a single free cell stage. In higher animals, just as we saw in the plants, there is besides a specialization of work among the cells.

If we now turn to the human body we find that there is a constant flow of amœba-like cells from the digestive cavity through the blood vessels. These cells are the so-called white corpuscles of the blood, and structurally they are identical with the free amœbæ, one kind of which we have been discussing. They take in foreign matter by absorption, and have independent movements like the free amœbæ which they chemically resemble. They have the power of changing form, and eventually they elongate themselves into a fine needle shape, and, penetrating through the walls of the capillary blood veins, they pass into the muscular tissue of the body, where they become quiescent and of which they afterward form a part. Thus is the human body increased. It is perfectly true that a man is a republic of amœba cells. Here all cells do not perform the same work, and there are special cells charged with the operation of reproduction or division. And it is perfectly true that puberty is the result of growth, just as in the free amœba cells. As soon as a certain stage of growth is reached all bodies tend to divide or throw out offspring.

The human body and the bodies of all animals are then found at last to be but an aggregation of cells. And there is this to be noted, that the nearer such cells are to the blood and the sources of their multiplication, the more alive they are. It is a fact that all the cells in our bodies are not equally alive, and that we carry around with us many that are dying and many that are already dead and decomposing.

But if we now take the development of the egg of a higher animal, such as the egg of a dog, we shall see that at first it has the amœba form. Afterwards it subdivides after the manner of euglæna. Its contents at its earliest stage are exactly like the contents of the amœba cell and that of all eggs at the time of their earliest formation. Further than this, it develops by division, and the embryo within the egg is really the result of such subdivision growing in complexity until a certain stage is reached. What that stage is to be, whether an amœba, a fish, a bird, a dog, or a man, cannot be determined from the organic contents of the original egg cell itself. It is, therefore, dependent upon the inherent energy of the particles themselves.

I have not been willing to take your attention away from the serious matter of this lecture by details of cell and egg formation, which do not affect the general argument. For instance, in amœba forms we have a pulsating contractile vacuole, a little spot of beating matter which has been fancied to resemble the heart. We have in the egg the different poles, the external membrane which in the chicken, for instance, can be infinitely subdivided, and is the finest example of fibrous tissue. These and others are all modifications of the protoplasmic mass, the result of changes among its particles.

Through the lower phases of animal life, and the details of physical structure, a lecturer can take his anecdotal way, rejoicing, amusing, and instructing his audiences. But in this lecture I have aimed to illustrate one point especially—the composition of the matter of life and its growth by absorbing allied substances, and the separation of fresh masses of it by division. The conditions which determine this division, whether we have a mass of unnucleated protoplasm, a cell, or an egg (which is a specialized cell), are simply the inherent energy in its atoms, and the resisting energy of the surrounding matter against which its energy is displayed.

We may conceive that development is determined by these conditions in the organic as well as the inorganic world. There is at the bottom one cause which makes matter into a mountain, a tree, or a man. Science, in detecting the process of evolution, asserts the unity of all nature. It is safe to say that the teleological school can never attain this view as a logical result. It has only recently been asserted that the movements of the free cell body in amœba forms are attended by a chemical change in the mass of the body particles at the points where the cell wall is altered in shape. This discovery is not so important as it might at first sight appear, because such a change is only another form of a movement which we can clearly see to take place under the microscope of the matter in the free moving cell. We must conclude that the movement of the cell or any group of cells, is the result of the movement of the particles which compose it, exactly as we found with regard to groups of matter in an inorganic condition. Further than this, we must believe that movement could never take place were it not permitted by the conditions about an organism itself.

Suppose we confine a man with iron bands to a floor of stone. His elastic frame is brought into opposition with a more rigid body which it cannot penetrate, the state of whose particles has no affinity for his own. He will be a prisoner for a while, until that form of motion which we call life ceases in him, and that other form of motion which we call death commences. But in a longer or a shorter period, he will escape his prison; particle by particle his body will reunite with other elements in the atmosphere about him in decomposition. Even the iron itself will give way at last and fall in rust apart. We have not been able to control the nature of things by our experiment, but we have effected a temporary displacement and a new condition or

environment about the man. Within such limits we can work for good or evil to our kind, and how blindly, and cruelly we have often worked I am reminded by my simile.

I endeavored to be clear in the first part of this lecture upon the composition of the matter which shows the kind of motion we call life. I tried to show that it was a very complex state of certain mineral or inorganic substances. Being so, it is not surprising that these inorganic substances, making up protoplasm, should change their relative position with regard to each other, according to their density. The moment this was done there was motion. Now these same inorganic substances in a different combination, and not in the shape of protoplasm, also move. We cannot conceive (as I have tried to show) of a state of permanent rest among the atoms of matter. Life thus inseparably connects itself with motion, and motion is the result of the relationship between different particles of matter.

I think the facts in the case allow us to come to this conclusion, and I think that this conclusion, by enabling us to bring our actions into accordance with the facts, will immeasurably help us in our social existence. All that is good and sweet in our lives will remain, and being purified from the fictitious charms of fancy, may well increase in every direction, until the sum of human happiness is raised to a more dignified total than it now presents. Meanwhile, we who are passing through a transitional period of knowledge, must get along with our necessarily incomplete ideas as well as we can, extending and expecting kindness and toleration, but sure that when we are increasing knowledge, we are advancing the best interests of the human race.

ON THE QUEEN BEE, WITH ESPECIAL REFERENCE TO THE FERTILIZATION OF HER EGGS.

By John Hunter.

The life history, functions, and attributes of the hive bee have for more than two thousand years engaged the attention of naturalists and other men of science. Apiarian students have numbered in their ranks men whose pre-eminent learning have left their names as landmarks to posterity, and who will never be forgotten while history exists. Among the ancient philosophers who have studied and written upon the bee, I may mention Virgil, who devoted the whole of his Fourth Georgic to the subject; Cicero, Pliny, Aristomachus, Philiscus, Columella, and Celsus; and within the present century we have the great naturalist, Swammerdam, the mathematician, Maraldi, Reaumur, the inventor of the thermometer which bears his name, my illustrious namesake, John Hunter, the anatomist, and Huber, of Genoa, whose total blindness did not prevent his giving to the world many facts in the bee's life history which were before unexpected. Without approaching nearer to our own time, the above array of brilliant names as examples will sufficiently excuse any amount of attention we lesser lights may give to an insect so small, but yet of great and increasing service to mankind.

When so many learned men have been before us, it may be assumed that the subject is well worn, but the fact is, that, from the imperfect means of observation enjoyed until lately, mainly by the misconstruction of hives, facts have been so mixed up with surmises and wrong deductions drawn, that it became a difficult task to separate the true from the false. A colony of bees consists of workers which may number fifty thousand or more, in summer a few hundred drones, and *one* queen, who is the only individual in all this vast assembly capable of propagating the species. At the present time, the month of October, we may safely assume that under normal circumstances the queen in any hive is the mother of every other bee there. The drones are males, and what I have just said will, of course, have informed you that the queen is a female; and the question naturally arises, what are the workers? They used to be styled neuters, but they are not so; they also, as well as the queen, are females, differing in the fact that their sexual organs are not fully developed. Drones, workers, and queens, of course, are all bred primarily from eggs, and those gentlemen who have made no special acquaintance with bee history, will perhaps feel surprised when I say that the eggs which produced the queen and the workers were, when deposited by the mother bee, identically of the same kind, and either could, at the will of the bees, who may even be influenced by the will of the bee master, by skillfully directing them, as his agents, be made to give birth to either queens or workers—nay, I will even go further, and say, that I believe it possible that the skillful experimentalist could so direct that some selected eggs, which, left to themselves, would give eventual birth to drones, should be made to produce drones, workers, or queens at will. To elucidate this problem, I must beg your attention while I trace the history of a bee, not only from the deposition of the egg, but from the growth of the latter in the ovary of the mother, and it will also involve an explanation of the theory of parthenogenesis.

On dissection of a queen, we find within her abdomen a pair of ovaries, as on the diagram to which I direct your attention, as also to the preparation of these organs under the microscope. We see each ovary consists of a great number of tubes, containing eggs in various stages of development, and all these tubes lead to a right or left duct, which again unites into one main channel down which the eggs pass; at the side of this latter duct we find a little globular sac opening into the oviduct; this sac is called the spermatheca, and is filled, when the queen has had copulation with the male, with the usual whitish seminal fluid, containing countless thousands of spermatozoa in full activity. I have here an impregnated queen, from which I will show you it is easy to dissect out the spermatheca, and verify its contents to be as I state. Seeing these active bodies all wriggling and twisting like so many eels, it is hard to believe they are not animalcules, as was long thought. To return to the eggs: when arrived at maturity they glide down the oviduct from either ovary, and on passing the opening of the spermatheca, receive one or more spermatozoa, which, penetrating the egg's substance, causes the birth of a worker larva; but it may so happen that the egg in its passage does not, either from volition or inability of the queen, receive impregnation; in this case it does not perish or addle, but gives birth to a drone larva; and it has been conclusively proved that the act of fertilization or not determines the sex of the future bee. The egg being fertilized and deposited, it hatches in about three days, and the young larva receives the careful attention of the worker bees, who feed it with appropriate food, and in due time it passes to the pupa state, on the twenty-first day becoming a worker bee; but the same egg that produced the worker in twenty-one days could, had the bees been so minded, have been bred up to a queen in sixteen days. The bees only rear queens when necessity calls for them, either from loss of their old monarch or apprehended swarming. If I remove the queen from a hive, the first of these contingencies occurs, and after a period of a few hours' commotion, the bees select certain of the workers' eggs, or even young larvæ, two or three days old, the cell is enlarged to five or six times its capacity, a superabundance of totally different food supplied, and the result is that, in five less days than would have been required for a worker, a queen is hatched. The marvel is inexplicable, how a mere change and greater abundance of food and more roomy lodging should so transform the internal and external organs of any living creature. The case is without a parallel in all the animal creation—it is not a mere superficial change that has been effected, but one that penetrates far below form and structure, to the very fountain of life itself. It is a transformation alike of function, of structure, and of instinct. On the birth of the queen her wings are limp, and hairs clotted with moisture, but she is in full activity, the workers assist in her release from the waxcell in which her transformation takes place, but they pay very little or no attention to her so long as she remains a virgin.

The impregnation of the queen bee was long an enigma to naturalists; some have denied that any intercourse with the male was necessary for the fecundation of the eggs. Some supposed that the effluvia arising from the males within the hive was sufficient for this purpose. Maraldi thought the eggs were fecundated by the drones after they were deposited, in the same way that the spawn of fishes is fecundated; but, from our extended means of observation, we are no longer in any doubt as to the *modus operandi*. From three to seven days after birth, the queen issues from the hive, on nuptial thoughts intent, and after circling a few times round her home, apparently taking its bearings, she flies away into space; if her trip be fortunate, and she meets a drone, they fall together to the ground, where separation quickly takes place, at once fatal to the drone, who parts with his sexual organs, which remain attached to the queen on her arrival home; these quickly shrivel up, and are removed by the workers. In the act of coition the spermatheca of the queen is injected with seminal fluid, and, wonderful to relate, this small vessel, whose external measurement is but 1-32 of an inch, contains sufficient material to fertilize all the eggs which the queen may lay in her whole life (for she mates but once), although she may live four or five years, and deposit during this time more than a million eggs. Dzierzon, a highly scientific German bee-master, says: "Most queens in spacious hives, at a favorable season, lay 60,000 eggs in a month, and a specially fertile queen in four years, which she on an average lives, lays over 1,000,000 eggs." On this authority I make this statement, and I do not think it is an exaggeration. Referring back to my text that "the act of fertilization (of the eggs) or not—determines the sex of the future bee," you may naturally ask how I prove this statement, or that the unfertilized eggs will hatch at all. Professor von Siebold made many most skillful microscopical dissections of eggs, and he affirms that among fifty-two eggs taken from worker cells, examined by him with the greatest care and conscientiousness, thirty-four furnished a positive result, namely, the existence of seminal filaments, in which movements could even be detected in three eggs, and among twenty-seven eggs from drone cells examined with the same care and by the same method, he did not find one single seminal filament in any egg, either internally or externally. A phenomenon sometimes occurs in a beehive of a queen laying eggs that produce males only; this for ages had puzzled philosophers, without any satisfactory solution, but if you will bear in mind what I have said, and admit it as fact, the solution is easy.

The theory of parthenogenesis (or virgin breeding) which Dzierzon promulgated in 1845, is said to have explained this phenomenon of the beehive as perfectly as the Copernican hypothesis the phenomena of the heavens. The principal points to bear in mind are—that the queen, to be able to breed workers, must be fertilized by the drone, and that the union takes place only in the air; that drone eggs do not require fecundation, but that the co-operation of the drone is absolutely necessary when worker bees are to be produced; that in mating the ovaries are not fecundated, but the seminal receptacle (the spermatheca), and that the supply of semen thus received is sufficient for her whole life-time. We prove these hypotheses as follows: Eggs laid in drone cells never produce aught but drones—a queen born with her wings imperfect, rendering her unable to fly, or one born after drones are all dead (generally by August), and consequently unable to mate, lays eggs indiscriminately in both drone and worker cells, but all alike produce drones. The verification of this is very easy; we have but to deprive a stock of its queen in the autumn, and, provided there are eggs in the hive, young queens are sure to be reared, and as surely they will become drone breeders; the experiment has been so many times repeated that the fact is now incontestable.

That a queen mates out once in her life, the introduction of the Ligurian bee into England enables us to prove. This variety has the reputation of being a better one than our own native bee—and it is a common practice to import annually from Italy fertile queens, which, by a little skillful management, are made to take the places of the rightful sovereigns in our English hives. The Ligurian bee is gayly striped with yellow bands, and we quickly find the original black bees are dying out, and replaced by the easily distinguished Italians, and while this naturalized queen lives, the bees of her hive are thoroughbred Italians. I will presently dissect out, and display the contents of the spermatheca of a fertile queen, which will exhibit many thousands of the spermatozoa, with their characteristic contorted movements. I will then perform the same operation on a virgin queen, when we shall find the contents of the spermatheca a limpid fluid only, not a trace of the spermatic filaments. My namesake, the great surgeon, attempted to fertilize drone eggs by artificial impregnation from the spermatheca of a queen. He failed with the bee, but succeeded with the silkworm moth. Dr. Dönoff is stated to have been more successful, and I see no reason why the experiment should at all times fail. Cases sometimes occur, when a hive is queenless, that one or more workers will develop the power of ovipositing; it is reasonable to suppose, from their diminutive size and general non-perfection of their organs, that the functions of the drone had not been performed; certain it is that eggs of a fertile worker produce drones only, and in one solitary case, where such a worker came into my hands for dissection, although I found ovaries and eggs, I could discover no spermatheca. It has been a common subject for authors to dilate upon the respect and reverence bees pay to their queen, and the valor with which they defend her. This, although very pretty, I am sorry to say, is all fable. The bees' attention to the queen is solely in interested motives, that is, care for the eggs. A virgin queen receives no attention whatever; no defense is ever offered for the queen. I never hesitate to pick up a queen from the midst of her subjects, to which the bees pay no heed, and in cases where an eruption of strange workers takes place in the hive, the rightful inhabitants will suffer their queen to be seized and ill-treated by the intruders without resentment. A queen is possessed of a sting, but I have never known her to use it as a weapon, except in combat with another queen; but it is probably used to direct her ovipositor when in use. —*Journal Quekett Microscopical Club.*

INSECT POWDER.

The insect powders of commerce are the powdered flowers of different species of *pyrethrum*. Those of *pyrethrum carneum* and *roseum* were introduced some thirty years ago under the name of Persian insect powder, and subsequently those of *pyrethrum cinerariæ folium*, a native of Dalmatia, Austria, as Dalmatian insect powder. Both the Persian and Dalmatian powders are good insecticides, but the latter is much the more energetic in its action and hence commands a higher price; indeed, it is so much preferred that it is gradually driving the so-called Persian powder out of the market. The fact of the flowers of *Poseum* being less active than those of *P. cinerariæ folium*, has been accounted for on the ground that the single flowers are much more powerful than the double ones, and that the double flowers occur in *P. roseum* in much larger proportion than in the other species. The flowers, either whole or powdered, preserve their activity for a long period.

Insect powders have not attracted general attention as insecticides until within the last three or four years, during which time they have been introduced in various forms in packages and boxes, accompanied by suitable blowers or insect guns for the purpose of properly distributing the powder, and recommended for the destruction of flies, cockroaches, fleas, bugs, etc. Sometimes these prepared articles have been artificially colored so as to disguise their source, but all have owed their activity solely to the presence of the powdered flowers of one or other of these *pyrethrums*.

House flies are very sensitive to the effects of these powders. A few puffs of the dust from an insect gun blown into the air of a room with the doors closed, the discharges directed towards those parts where flies are congregated, will stupefy and kill them within a very short time. The powder is somewhat pungent, and to breathe an atmosphere charged with it will frequently cause a slight sneezing, but beyond this the operator need not anticipate any annoyance. Frequently during the past summer, when flies have been troublesome, we have pretty thoroughly charged the air in our dining-room and kitchen at night, closing the doors, and in the morning found all, or nearly all, the flies lying dead on the floor. A few minutes after its use they begin to drop on their backs, and after using the powder, few, if any, will escape. By some this energetic action has been attributed to the presence of a volatile oil in the flowers, by other and later investigators to a peculiar crystalline principle believed to be an alkaloid; but this point does not as yet seem to be fully settled.

More recently we have been experimenting with this powder on the green aphis which troubles our green-house plants. The usual plan of smoking tobacco is an unpleasant remedy, and is also very injurious to plants of delicate constitution, whereas the insect powder used to any extent is perfectly harmless to plant-life. After freely charging the air of a green-house with the powder, blowing it in fine clouds of dust among the plants, the tiny tormentors who are busily engaged in sucking the life out of the leaves and tender shoots soon manifest symptoms of uneasiness and begin to drop from the plants to the ground, and in the course of an hour or two the larger portion of the enemy's forces will be found lying sprawling on the earth in the pots or on the shelves and floor of the house, where, probably partly from the stupefying effects of the powder, and partly from their natural inability to find their way to any given point, they fail to reach the plants again and hence perish. By applying the powder freely in the evening and giving the plants a thorough syringing in the morning, they may in the worst cases be almost freed from aphides by a single application, it is better, however, to repeat its use the next evening, so as to make sure work.

This matter is well worthy the attention of all those who indulge in window gardening, or who grow plants in small conservatories attached to dwellings, since if this proves an efficient and economical substitute for tobacco smoke, it will save much annoyance and some loss. Success will necessarily depend on the quality of the material used, but after the experiments we have tried we feel confident that with good Dalmatian powder there need be no failure.—*Canadian Entomologist.*

Crystallogenesis.—Lecoq de Boisbaudran.—Since the resistance to a change of condition is not alike for the different planes of the same crystal, its solubility must vary with its outward form. Thus a supersaturated solution of basic alum being treated at a given temperature with cubes of this salt (or with portions cut according to the cubic surfaces) will not possess the same specific gravity as in cases where the desupersaturation has been effected by contact with octahedra (or portions cut according to the octahedral surfaces). The former liquid will be more concentrated than the latter, and after it has ceased giving up matter to the cubes it will still be capable of depositing upon octahedra. Even if we consider a single system of surfaces only the principle of resistance to a change of condition leads us to recognize two unequal specific gravities for a saturated liquid at a given temperature, according as we begin with a dilute or a supersaturated solution. The solubility of any substance is therefore not sufficiently defined by the quantity contained in the liquid at a given temperature in presence of an excess of the solid substance. We must further specify the species of surfaces and the direction in which the operation has been conducted. If the desupersaturation of a solution is obtained by means of crystals having several orders of surfaces there are two possible cases: (1) The quantity of liquid is great in proportion to the immersed masses; the crystals then assume their most stable form, and the final specific gravity is what corresponds to this system of surfaces. (2.) The quantity of liquid is very limited; the crystals cannot in these conditions assimilate matter enough to complete their form of maximum stability, and several orders of surfaces subsist indefinitely: the final specific gravity is that which corresponds to the system of surfaces destined to disappear first if the crystals could continue to grow.

Scandium, a New Element.—L. F. Nilson.—The author has extracted from impure erbia a substance whose spectroscopic behavior indicates its novelty. Its atomic weight calculated for the formula of the earth ScO is below 90.